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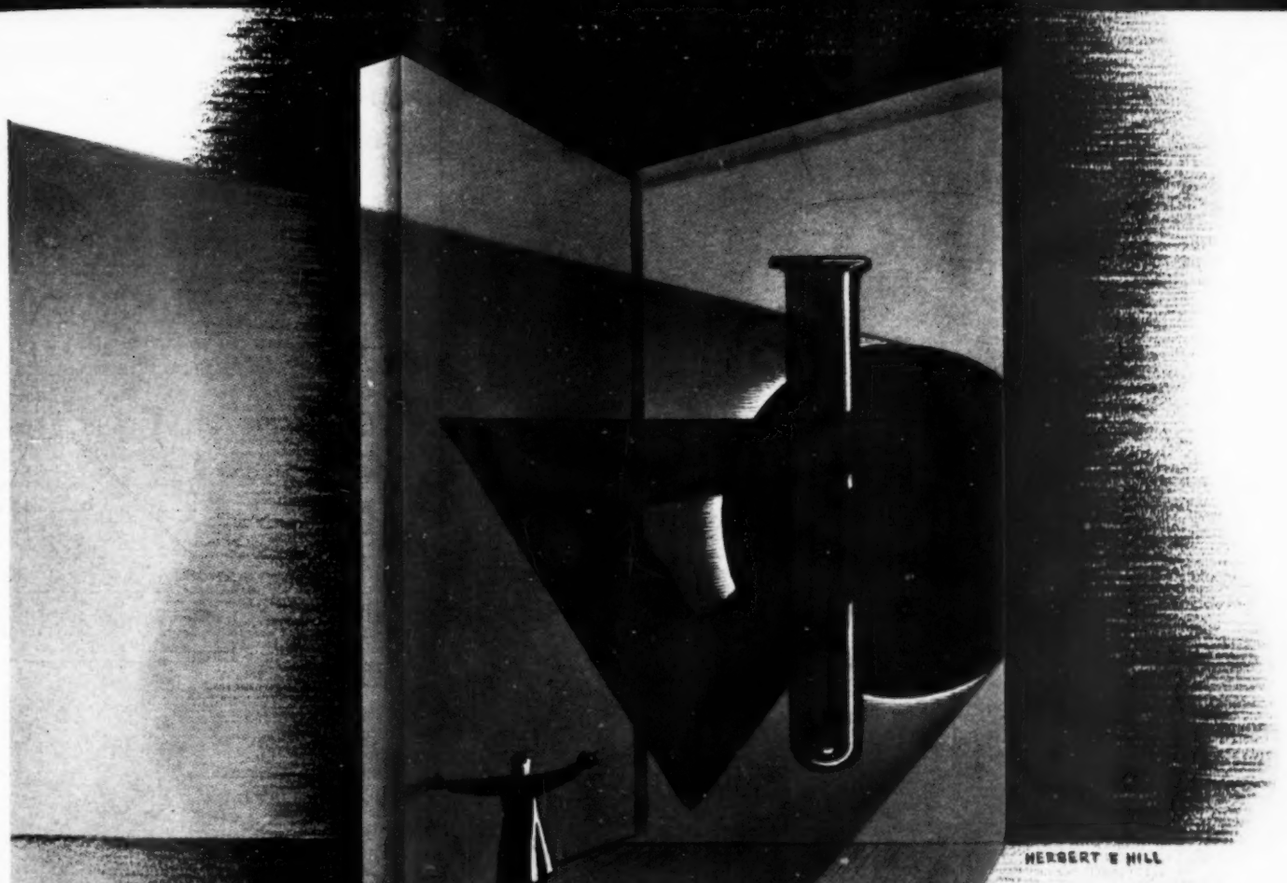

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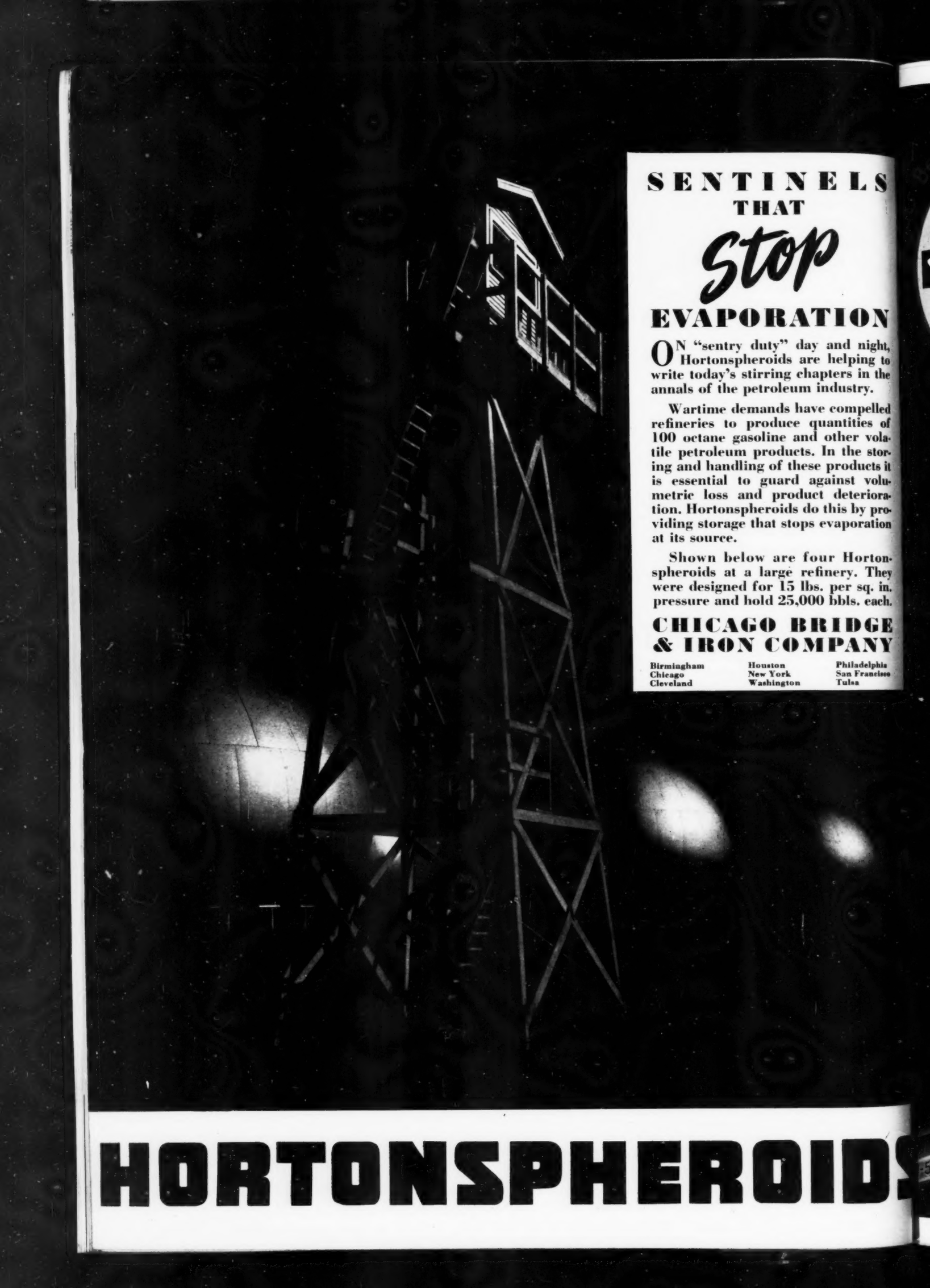

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THE Petroleum Engineer

VOL. XIV No. 9

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MEMBER A.B.C.—A.B.P.

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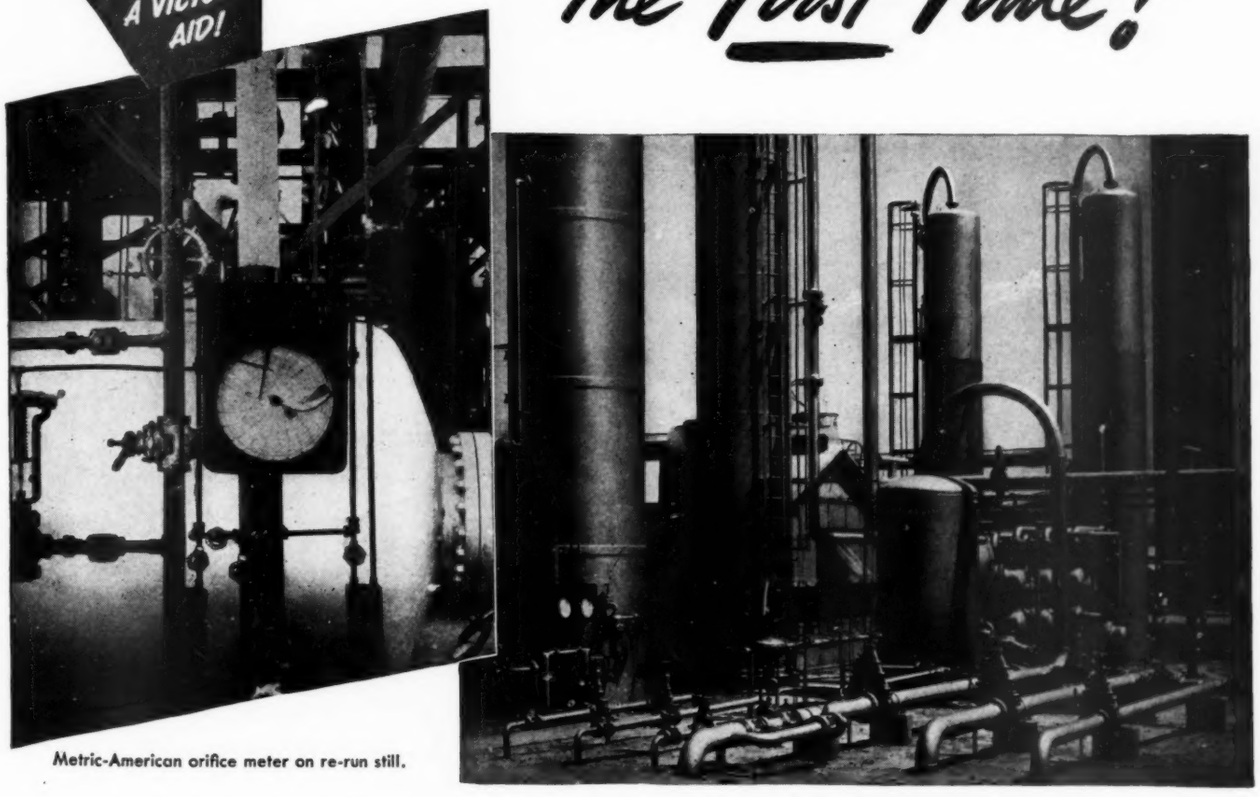

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1934

The Course of Oil

by K. C. SCLATER

PROBLEMS FACING PRODUCERS

In addressing the Independent Petroleum Association of America at St. Louis last month on realistic planning needed for the critical and complex period after war, Paul Ryan, chairman of the Committee on Postwar Planning, Petroleum Industry War Council, stated some of the problems that petroleum economists recognize now face the independent oil producer during the war and in the postwar period. These problems involve questions of paramount and far-reaching importance not only to independent producers but to every producer of petroleum in the nation. They merit close study and consideration.

"It is regrettable that the Administration's difficulties with the labor unions in the coal industry precluded, for the time being, a satisfactory answer to the eloquent plea of the Petroleum Administrator for an increase in price of crude oil. Not only the negativity of the OPA's answer, but its consummate impracticality and its lack of adequate understanding of the realities of the oil industry combined to distract the industry from its main task of trying to produce adequate supplies of oil to assure victory in this war.

"Since OPA refuses to allow the price of crude oil to advance even part-way towards the advanced price level of other commodities as determined by OPA, how is the independent producer to continue trying to produce increasing quantities of oil with continuously and more rapidly increasing costs of operation?

"How can adequate volumes of production be maintained at the present peak levels, when new reserves each year become more difficult to locate, more costly to produce, and apparently much reduced in volume?

"Will there be adequate supplies of oil and its products, during the war to satisfy the military demands of our armed forces and simultaneously answer our reduced civilian needs?

"If adequate supplies are not foreseeable, does not national self-preservation demand that steps be taken to obtain such supplies? To achieve increased production of any commodity in a democratic capitalistic system, what incentive can compare with increased price for the product as a time-tested, equitable, economical method free from the implications of government control, politics, favoritism and scandals?

"Will the price of crude oil, which is controlled by governmental fiat during the war and which may be largely influenced after the war by the forces of a freer economy, rise enough to warrant the intense utilization of methods of secondary recovery, thus freeing from the ground billions of barrels of precious oil that otherwise might never be recovered?

"Will not the ultimately-expanded postwar industrial activity demand increasing amounts of petroleum products—gasolines, lubricants, fuels, and other products? If so, is it not conceivable that crude oil prices will automatically rise to a price level approaching that of other commodities when inordinate governmental controls are somewhat relaxed to the point where their exercise, freed of political complications, is needed solely to prevent inflation?

"If postwar industrial markets absorb increasing amounts of petroleum products as bases for transportation, manufacturing, chemicals, synthetics, plastics, etc. —some of which in their present stage of development may be small users of petroleum products—is it not reasonable to assume that the high-profit demands for even comparatively small volumes of petroleum will favorably affect crude oil prices?

"In the postwa. period, therefore, if adequate economical transportation facilities are available, could not producers try more than in the past to sell their production to refiners who satisfy more of these higher-priced products markets, so that the refiners could pay a higher price for his purchased crude oil?

"If these higher-priced and greater-volume postwar demands result, and if our present rate of discovery of crude oil continues at its present comparatively low level, could not producers well consider refraining from selling their production to refiners who resell this valuable production as cheap heavy fuel oil?

"Will not the application of catalytic cracking methods make the conversion of heavy fuel oil into higher-priced gasolines more profitable for the refiner, and allow him to pay the producer a better price for his crude oil?

"Will not the postwar demands for higher-priced petroleum products almost preclude the use of our domestic production as a source of low-priced cheap, heavy fuel oil, on our East Coast? If our domestic production is inadequate in volume and too valuable in price to be sold as cheap heavy fuel oil, is it not wiser to import such low-priced heavy fuel oil to be used in some of our East Coast industries and retain such business within the oil industry, rather than allow the coal industry to replace this cheap heavy fuel oil by coal? Why lose the oil industry's market to coal when cheap heavy fuel oil, competitive in price with coal, may be readily available?

"Since the United States has about one quarter of the known oil resources of the world, and annually uses itself about three quarters of the world's consumption, is it not wise to plan now and during our postwar period, to supplement eventually our reducing supply by imports that will satisfy the cheaper, lower-priced, industrial fuel markets on the East Coast and retain for our domestic production the higher-priced valuable markets that the geniuses of our American industry are developing and expanding?"

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Highlights IN OILDOM

Bottom-Hole Pressure Declines at Hawkins

Bottom-hole pressure has declined 27.39 lb. in the Hawkins field, Texas, data released by the Texas Railroad Commission reveals. Tests made by that body show an average field pressure of 1788.31 lb. compared with 1815.70 lb. in December. Sixty-five wells were tested in the latest survey whereas 57 were tested last December.

Investigating Gasoline Deterioration

Petroleum engineers of the University of Texas have been authorized to expand their investigations into the deterioration of aviation gasoline—one of the major problems faced by the armed forces in transporting high-octane fuel from this country to foreign bases.

The University Research Institute has authorized Dr. H. H. Power, chairman of the Petroleum Engineering Department, to continue his work on deterioration, and to expand his project to include the effect of bacteria on hydrocarbons contained in aviation gasoline.

Dr. Power and Fraser H. Allen, Ethyl research fellow at the university, have recently completed studies on the effect of water on stability of motor fuels in storage. In their studies they found that intensive drying of a gasoline—removal of all water—greatly reduced the rate of gum and peroxide formation in stored gasoline, and that saturation of gasoline with water promoted deterioration.

As a result of their work to date, they have suggested that gasoline could be dried and stored in contact or above water, but not mixed with the water. They found this a workable plan. Mixing the water with the gasoline, however, brings on deterioration, they found, and causes the high-octane gasoline to decrease in effectiveness.

Commission's Drilling Orders Upheld

The United States Supreme Court has dismissed attacks filed by oil companies against orders by the Texas Railroad Commission permitting the drilling of additional oil wells. Justice Black delivered the decision, asserting that "a sound respect for the independence of state action requires the federal equity court to stay its hand."

The majority opinion directed dismissal of the suits by the Federal District Court in which they were filed originally by the oil companies.

The state railroad commission orders permitted O. L. Hastings and C. F. Dodson to drill a second oil well on 8.85 acres and authorized G. E. Burford to drill four oil wells on 2.33 acres in the East Texas oil fields.

The order applying to Hastings and Dodson was challenged by the Selby Oil and Gas Company and the Lewis Production Company.

The oil companies contended the order violated the 10-acre spacing rule, which they said could be waived only to prevent waste or confiscation of property. The tract is in Rusk County.

Originally judgment was granted by the district court for Hastings and Dodson without hearing their evidence. The circuit court ruled that a trial should be held.

The order applying to Burford was challenged by the Sun Oil Company and the Magnolia Petroleum Company. They also contended the order violated the 10-acre spacing rule. The tract is in Gregg County.

Originally the district court dismissed the complaint, but the circuit court directed a new trial.

Proposes 70-Cent Increase in Oil Price

Representative Wesley E. Disney of Oklahoma early this month introduced a bill in the House of Representatives proposing an increase of 70 cents a bbl. in the price of crude oil. Oil price control would be transferred from the Office of Price Administrator to the Office of Petroleum Administrator for War, according to the provisions of the bill. A formula for fixing ceiling prices on oil is also prescribed.

In a statement Disney said purpose of the legislation is to avert insofar as possible "the fast-approaching national disaster in petroleum supply."

"The damage that has already been done through a price policy which has taken no account of the facts is serious," he continued. "We are rapidly exhausting our ability to produce daily the increasing amounts of crude oil required by the accelerated pace of the war.

"It will be of no use to keep on increasing the means of transporting petroleum, of building new pipe-line systems, and speeding up the movement of tank cars and inland waterway facilities, unless there is oil to transport.

"It is axiomatic that production of any commodity or any raw material will not be increased, or even maintained, if a considerable portion of it is being sold at less than cost. That is the situation today with the production of crude oil."

Compact to Meet in Pennsylvania

Pennsylvania, the cradle of the oil industry, where Colonel Drake drilled the world's first producing oil well, will be host to the summer quarterly meeting of the Interstate Oil Compact Commission, Governor Andrew F. Schoeppel, of Kansas, Commission chairman, has announced.

Meeting in open session in Pittsburgh's William Penn Hotel June 26, the Commission will hear eminent authorities discuss war and post-war problems of the petroleum industry and ways and means to alleviate critical shortages of gasoline and fuel oil.

Members of the Commission will attend sessions of the annual meeting of the Pennsylvania Grade Crude Oil Association in the William Penn Hotel Friday, June 25. Members of that association are expected to remain over for the general session of the Compact Commission Saturday.

Official representatives from Ohio, who recently enacted legislation authorizing Ohio's membership in the Compact, will meet with the Commission for the first time. Ohio becomes the thirteenth state to join in the Compact.

U. S. Lends Money to Mexico Oil Industry

The newspaper *Excelsior* of Mexico City, quoting "an authorized spokesman of Petroleos Mexicanos," says that the United States government has extended to the Mexican oil industry "credits sufficient for its stabilization." The newspaper adds that the current deficit of Petroleos Mexicanos (the government oil industry) amounts to $60,000,000 due to "unusual outputs" since the expropriation of foreign oil companies in 1938.

Expenditures listed include indemnization of expropriated companies, and "expenses of refining our oil in Houston, Texas." Other factors cited are wartime restrictions on foreign trade, and loss of $4,000,000 worth of materials due from Axis nations in trades before the war.

The credits from the United States will be used, the account states, for acquisition of new equipment, construction of a high-octane gasoline refinery, modernization of oil fields, acquisition of transportation facilities, and other projects.

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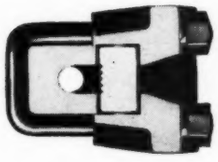

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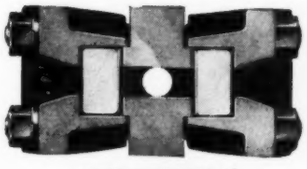

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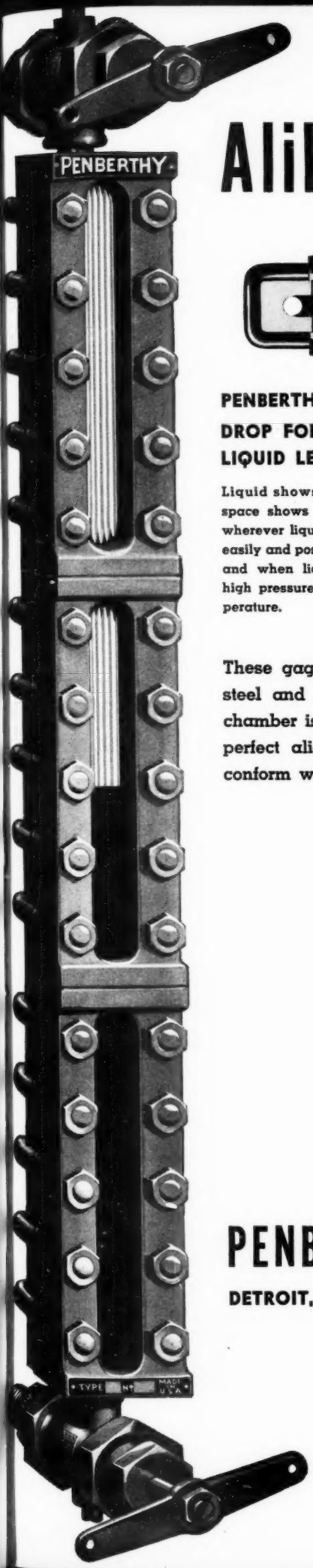

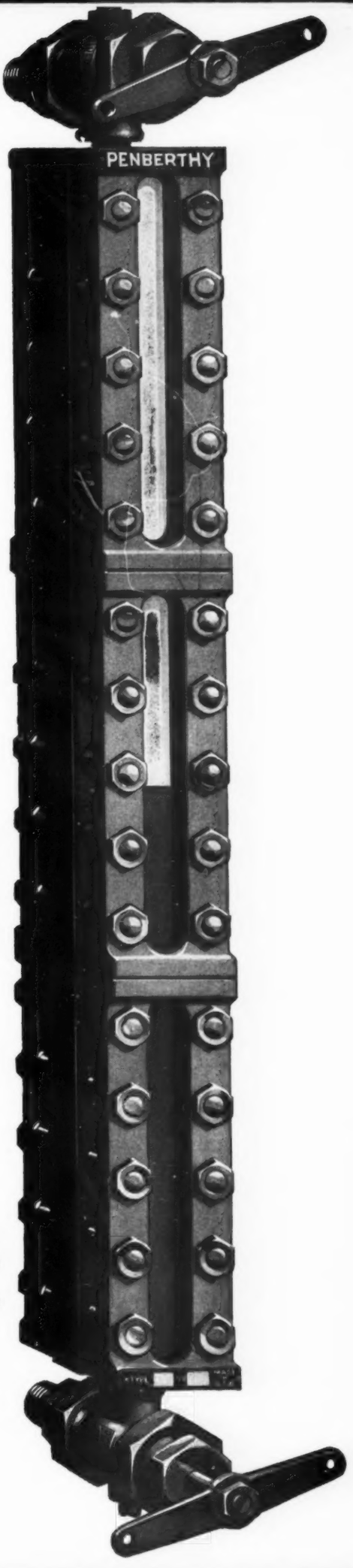

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MAJOR *Refining* ACTIVITIES

ALL refinery operations in the Middle West (District Two) have been placed on a quota basis to meet a developing crude oil shortage. The action, taken by Petroleum Administrator for War Harold L. Ickes, is expected to halt a progressive decline in crude oil inventories and to assure war refineries of the minimum amounts of crude oil they need to produce the maximum quantity of petroleum war products, including 100-octane aviation gasoline.

On the basis of these quotas it is estimated that all refineries now operating can operate at a level of at least 80 percent of the normal rate of the 18-month period, July 1, 1941, to December 31, 1942. War plants that require more than 80 percent of the normal rate to maintain maximum production of war products can receive additional crude necessary to maintain such production.

District Two refiners had been processing from 30,000 to 50,000 bbl. more crude per day than could be supplied by local production plus imports from other districts, Administrator Ickes said, and for that reason the decision was taken to allocate specific amounts of crude oil to individual refineries. The progressive decline of crude oil inventories had brought them to the lowest level in recent years. Indications pointed to a trend that would double the rate of withdrawal within the next 12 months, Ickes stated, unless the supply was allocated.

Completion of all its commitments to the government for the construction of butadiene plants at Baton Rouge, Louisiana, for manufacturing raw material for Buna-S synthetic rubber, has been announced by Standard Oil Company (New Jersey), as a fifth plant in the southern city was put in full operation. The fifth plant is the first large government-financed plant of this type to be finished and placed in operation by the oil industry.

The announcement was made in a telegram from R. W. Gallagher, president of Standard of New Jersey, to W. M. Jeffers, rubber director.

The five butadiene plants at the refinery of the Standard Oil Company of Louisiana, subsidiary of Standard Oil Company (New Jersey), have an annual capacity sufficient to make several millions of automobile tires.

Of the five plants, two were financed entirely by Standard Oil Company (New Jersey), another is owned by Defense Plant Corporation, and two others were built or equipped coöperatively by the company and government. All told the company has invested $12,050,600 in these plants and the government $11,507,000.

Buna-S rubber is the backbone of the government's synthetic rubber program, and butadiene is its basic raw material. The five plants at Baton Rouge employ two types of process for manufacturing butadiene — one process whereby butadiene is made by straight cracking of oil and the other a process for making it from butene.

Death of Dr. Hamilton Perkins Cady, University of Kansas chemist who discovered helium in natural gas in Kansas, recalls that event of 1907. Helium had been seen only on the sun by scientists. When a natural gas producer came in at Dexter, Kansas, and the gas failed to burn, Dr. Cady and Dr. D. F. McFarland were called from Kansas University to examine the cause. They discovered helium in large quantities and later a helium plant was established in that area. Dr. Cady was 68 at the time of his death, May 26, and he had been teaching at Kansas University 44 years.

Work was halted on an addition and alteration to a polymerization gasoline unit of the Arkansas Fuel Oil Company, Shreveport, Louisiana, when the War Production Board revoked its preference ratings May 18. The plant was to produce butadiene. Indications that the project could not be completed in time to be fully effective in the war effort was given as the reason for the change in orders. Estimated total cost of the work was $315,359.

A new unit for the production of codimer has been completed by Bay Petroleum Corporation at the McPherson, Kansas, refinery. Some new construction and conversion of old facilities made the addition which went immediately into operation and is producing components for aviation gasoline. C. O. Garbrecht of Denver, Colorado, is general superintendent for the company.

Standard Oil Company of Louisiana's commercial butyl synthetic rubber plant at Baton Rouge has gone into operation, the first of its kind in the nation. The plant has a 7000-ton capacity and the output is said to have equaled expectations. President of Standard of Louisiana, M. J. Rathbone, said that two other butyl plants are under construction in the same area, one with 7000-ton capacity and the second with 24,000-ton capacity.

With the Humble Oil and Refining Company's 30,000-ton unit being built at Baytown, Texas, the plants represent 10 percent of the government synthetic rubber program. All four are expected to be operating by the end of this year. Each of the 7000-ton plants can be converted to 24,000-ton production.

Completion of the four plants at the 68,000-ton level would provide the nation with a potential of about 325,000,000,000 tire miles a year, it was said. By the end of 1943 rubber production in Baton Rouge will rise to more than 70,000 tons a year. This estimate includes 38,000 tons of butyl from Standard's three plants, 30,000 tons of Buna-S rubber in the copolymer plant now in production, and 3650 tons of Buna-N rubber from the Standard Oil plant which has been in operation for more than two years.

Crude Runs to Stills, Production[1] and Stocks[2] of Motor Fuels
Week Ended May 29, 1943
A.P.I. Figures
(Figures in thousands of bbl. 42 gal. each)

DISTRICT	Percent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Production	Total Gas and Fuel Oil Stocks
*Combined: East Coast, Texas Gulf, Louisiana Gulf, North Louisiana-Arkansas, and Inland Texas	88.7	1,730	70.8	11,312	61,398
Appalachian	84.8	159	89.8	831	4,031
Ind., Ill., Ky.	85.2	702	85.2	4,275	27,367
Okla., Kans., Mo.	80.1	318	76.4	1,898	10,191
Rocky Mountain	49.0	85	57.8	591	2,911
California	89.9	685	83.8	4,669	83,931
TOTAL U. S.— B. OF M. BASIS MAY 29, 1943	86.2	3,679	76.2	23,576	189,829
TOTAL U. S.— B. OF M. BASIS MAY 22, 1943	86.2	3,698	76.6	22,877	191,136
U. S. B. OF M. BASIS MAY 30, 1942	.....	3,521	.....	21,802	213,757

*At the request of the Petroleum Administration for War.

[1]Production—total of gasoline at refineries including natural and blended; kerosine, gas oil and distillate fuel, and residual fuel oil.

[2]Stocks—at refineries, bulk terminals, in transit, and pipe lines of finished and unfinished gasoline; kerosine, gas oil and distillate fuel, and residual fuel oil.

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MAJOR *Oil Field* ACTIVITIES

• **Texas.** Clay County has a new pool with the completion of the Omohundro-Continental Stephens No. 1 wildcat, G. W. Stipps survey, 4 miles north of Buffalo Springs. The test showed 350 bbl. daily through 1-in. tubing from the Chappel formation at 6011-49 ft.

• **Oklahoma.** Price No. 1, NEC 29-7n-10e, east of Holdenville, blew in from 3882 ft. in the Cromwell sand. The Deep Rock Oil Corporation and Burke-Greis Oil Corporation wildcat proves another rich Cromwell sand pool for central Oklahoma. Production was 24 bbl. after the hole was cleaned.

• **Texas.** A new pool in the Wilcox sand was discovered in the old shallow Slick pool, Goliad County. The strike was Continental Oil Company Woods Estate No. 1, CEPI&M survey. Drilled to 8003 ft., the well was completed at 7600-20 ft. in the Wilcox formation for 250 bbl. daily.

• **Kansas.** Marion County has a new pool opener in the Rogers No. 1, CSL SE 10-14-14w, northwest of the Lost Springs pool. The Derby Oil Company wildcat has been assigned a working potential of 100 bbl. daily, producing from the Mississippi chat at 2346-65 ft.

• **Louisiana.** Acadia Parish was given a new gas and condensate pool by the Sun Oil Company Daily and others No. 1, 31-9s-1w, which flowed 82 bbl. of distillate in 21 hr. through a 1/8-in. choke. Total depth of the well is 11,199 ft.

• **Texas.** Little Wichita field is the name given a new pool in the Caddo lime opened up by Phillips Petroleum Company L. F. Wilson No. 1, section 117, ATNCL survey, Archer County. Official test showed 109 bbl. in 7 hours from perforations at 4881-91 ft.

• **Illinois.** Despite mud from floods the Lincoln Waggoner wildcat, John Pilcher No. 1, C SW NW 13-5n-5e, came in without acidizing, flowing through tubing at the rate of 800 bbl. daily from the McClosky lime. It is located more than a mile east of the Iola pool.

• **Oklahoma.** W. A. Davidson, dairyman and rancher, purchased a lease at the Osage sale for $200, and proceeded to drill a well for gas because he needed it for his home and dairy. The well opened a new shallow pool in southeastern Osage county. Located in SW SE SW 6-20-12e, the well is drilled-in at 1518 ft. and flows an estimated 200 bbl. a day.

• **Texas.** Jefferson County had a dramatic pool opener when the J. M. Hebert Estate No. 1, in the W. N. Sigler survey near Port Acres, blew in, spraying gas, shale, water, and oil over the derrick. The wildcat was drilled by Glenn H. McCarthy, Houston independent operator. The blow is believed to be coming from about 9900 ft.; total depth of the well is said to be 10,256 ft.

• **Kansas.** Hartman and Blair opened a new pool for Russell County with Sam Boxberger No. 1, SWC SE 10-14-4w, one mile east of Williamson. The well drew an initial potential of 108 bbl. of oil daily, producing from the basal sand at 3267 ft.

• **Louisiana.** A new gas condensate field has been opened by the Dr. Charles-Community, a wildcat in the South Leonville area of St. Landry Parish, Southwest Louisiana, 23-7s-5e. J. S. Abercrombie and Atlatl Royalty Corporation drilled to 10,223 ft., the gas sand being at 9575-90 ft. A show of oil was had at 10,010-20 ft.

AVERAGE CRUDE OIL PRICES

California	
Kettleman Hills	$1.23-1.29
Playa Del Rey	.80- .87
Coalinga	.73-1.13
Wilmington	.68-1.24
Montana	1.00-1.15
Wyoming	.45-1.15
Colorado	1.05-1.07
New Mexico	.70-1.15
Texas	
North Central	.97-1.25
Panhandle	.70-1.12
West Texas	.80-1.27
Gulf Coast	.93-1.48
Darst Creek	1.14
East Texas	.80-1.27
Talco	.79
Kansas	.93-1.25
Oklahoma	.75-1.25
Arkansas	.94-1.36
Louisiana	
Rodessa	$ .88-1.20
Gulf Coast	.93-1.36
North Louisiana	.98-1.30
Illinois	1.22-1.37
Kentucky	1.32-1.43
Indiana	.85-1.25
Ohio	
Lima	1.50-1.60
Michigan	1.24-1.44
Pennsylvania	
Bradford	3.00
Southwest	2.65
Eureka	2.59
Buckeye	2.30
Corning	1.31

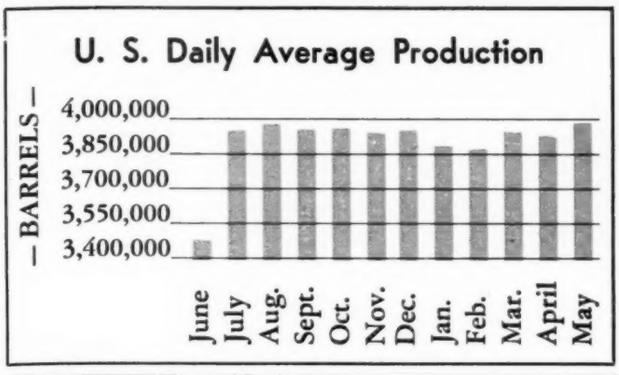
DAILY AVERAGE CRUDE OIL PRODUCTION
Data Supplied by A.P.I.
(Figures in bbl. of 42 gal. each)

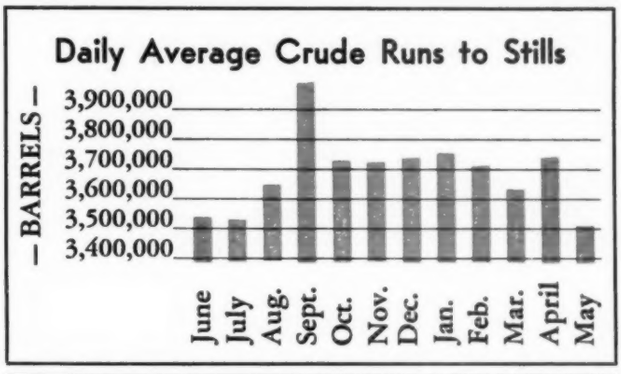
	[1]P.A.W. Recommendations May	Week Ended May 29, 1943	Week Ended April 24, 1943	Week Ended May 30, 1942
Oklahoma	379,000	[2]323,250	341,450	383,250
Kansas	309,700	[2]299,450	318,800	256,500
Nebraska	2,400	[2] 2,050	2,200	4,000
Panhandle Texas		91,100	91,000	98,000
North Texas		131,750	134,950	155,950
West Texas		226,750	214,450	210,000
East Central Texas		124,300	99,700	100,050
East Texas		339,300	319,800	495,000
Southwest Texas		214,000	188,500	165,950
Coastal Texas		375,200	340,750	324,850
TOTAL TEXAS	1,622,000	1,502,400	1,389,150	1,549,800
North Louisiana		87,050	88,400	86,550
Coastal Louisiana		261,050	257,900	208,150
TOTAL LA.	359,300	348,100	346,300	294,700
Arkansas	73,000	72,900	72,200	72,750
Mississippi	50,000	54,000	53,650	82,000
Illinois	250,800	211,550	225,250	288,450
Indiana	16,000	13,650	12,300	21,300
Eastern (Not incl. Ill., Ind., Ky.)	92,200	79,700	75,700	89,800
Kentucky	23,500	21,950	21,150	11,200
Michigan	62,100	61,700	57,100	64,400
Wyoming	97,000	92,100	92,300	93,350
Montana	24,600	20,900	20,250	21,700
Colorado	7,400	6,650	6,850	6,350
New Mexico	105,700	96,850	97,250	54,450
TOTAL EAST OF CALIF.	3,474,700	3,207,200	3,131,900	3,294,000
California	822,700	763,100	780,700	583,300
TOTAL U. S.	4,297,400	3,970,300	3,912,600	3,877,300

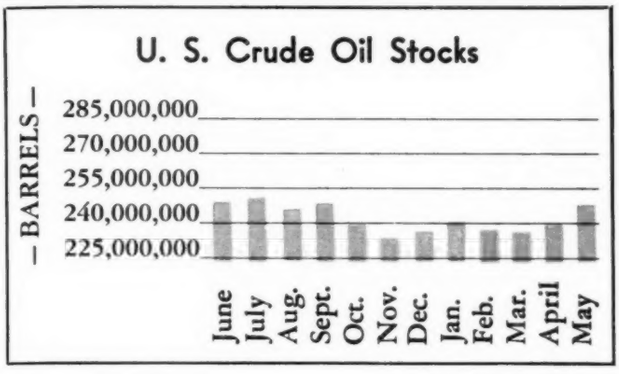
[1]P.A.W. recommendations and state allowables represent the production of all petroleum liquids, including crude oil, condensate and natural gas derivatives recovered from oil, condensate and gas fields. Past records of production indicate, however, that certain wells may be incapable of producing the allowables granted, or may be limited by pipeline proration. Actual state production would, under such conditions, prove to be less than the allowables. The Bureau of Mines reported the daily average production of natural gasoline and allied products in February, 1943, as follows: Oklahoma, 29,200; Kansas, 6,300; Texas, 103,100; Louisiana, 20,400; Arkansas, 2,800; Illinois, 10,800; Eastern (not including Illinois, Indiana or Kentucky), 10,000; Kentucky, 3,300; Michigan, 100; Wyoming, 2,300; Montana, 300; New Mexico, 5,500; California, 43,000.

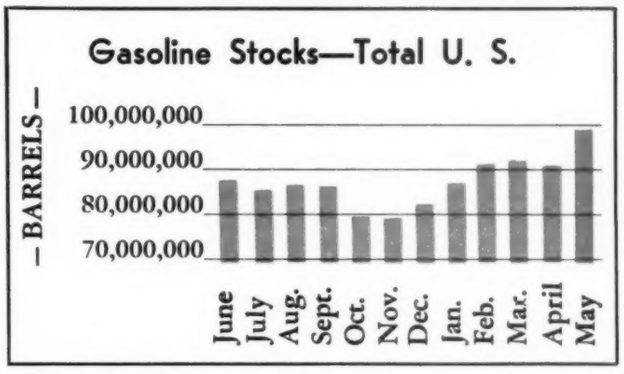
[2]Oklahoma, Kansas, Nebraska figures are for week ended 7 a. m., May 27.

PETROLEUM *Statistics* AND FIELD *Operations*









Above statistics by American Petroleum Institute.

Summarized Operations in Active Fields for May, 1943

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
Eastern Texas	22	16	6	....	3500-3700	2	40	Rotary
Gaines County	4	2	5	....	4400-5584	2	22-35	Rotary
Hockley County	5	3	3	....	4800-6850	2	20-30	Rotary
Ector County	3	1	5	....	3675-4377	2 or 3	32-36	Rotary
Panhandle	14	10	4	....	1700-3900	2	40	Rot.-Cab.
Nueces County	5	5	6	....	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	4	4	4	....	3730-2935	2	42-43	Rot.-Cab.
Hawkins Field	4	4	4	....	4495-4912	2	19-29	Rotary
OKLAHOMA								
Okfuskee County	2	2	6	4	2150-4125	2 or 3	38	Rotary
KANSAS								
Russell County	7	4	5	....	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	6	5	5	....	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	4	2	3	....	3290-3518	2	39-42	Rot.-Cab.
ILLINOIS								
Central Illinois	138	118	66	124	1425-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	11	8	6	3	3150-4030	2	30-34	Rot.-Cab.
CALIFORNIA								
Kern County	3	3	5	1	1840-11,450	3 or 4	14-30	Rotary
Wilmington County	4	2	4	3	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for May, 1943

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1942 (In Barrels)
	May	April	May	April	May	April	May	April	May	April	
Arkansas	22	20	15	6	14	6	8	3	18	4	26,560,000
California	103	56	87	44	11	12	28	21	28	15	248,250,000
Illinois	138	147	118	104	37	36	66	60	124	126	105,768,000
Indiana	20	25	8	18	9	18	6	4	3	3	6,680,000
Kansas	120	141	81	97	43	41	12	15	19	12	96,920,000
Kentucky	18	6	14	4	0	1	....	....	....	....	4,503,000
Louisiana	122	153	93	102	28	51	10	18	29	9	125,450,000
Michigan	33	20	24	16	5	6	9	11	....	4	21,568,000
Mississippi	....	6	....	3	....	....	....	....	....	....	27,605,000
Montana	3	10	2	4	....	....	....	....	....	....	8,998,000
Nebraska	....	1	....	1	1	2	....	....	....	....	1,367,000
New Mexico	23	33	16	25	11	23	....	....	....	....	31,875,000
New York	88*	74*	73*	61*	43	50	....	....	....	....	5,132,000
Ohio	63	54	51	43	47	32	....	....	....	....	3,480,000
Oklahoma	97	127	76	116	15	24	11	1	58	41	138,750,000
Pennsylvania	177*	111*	158*	94*	118	110	....	....	....	....	17,256,000
Texas	311	296	211	171	261	290	279	301	198	180	476,560,000
West Virginia	36	26	25	19	14	3	8	6	11	3	3,780,000
Wyoming	2	2	....	1	3	1	....	1	....	....	32,778,000
Total	1376	1308	1052	929	669	706	437	441	488	397	1,383,280,000

*Includes water-intake and pressure wells.

MAJOR *Pipe Line* ACTIVITIES

CONSTRUCTION of a 383-mile, 16-in. pipe line from Sundown, Texas, to Drumright, Oklahoma, having an initial capacity of 54,000 bbl. of crude oil daily, has been approved by the War Production Board upon the recommendation of Petroleum Administrator for War Harold L. Ickes.

Administrator Ickes said that materials for the line, which will be built and operated by the Stanolind Pipe Line Company, will be made available from PAW's controlled materials allotment. Construction is expected to begin early in October and the pipe line should be in operation sometime in March of next year, provided materials and workmen are available on schedule. Approximately 44,600 tons of steel and $7,000,000 will be required to build the new line.

The pipe line will serve to provide Middlewestern refineries with additional supplies of West Texas crude oil, thus meeting oil requirements in the Mid-Continent area, where crude oil reserves are declining.

Oil for the new pipe line will be taken from the Permian Basin area of West Texas, one of the last substantial crude oil reserves with producing capacity in excess of present pipe line outlets yet developed in the Southwest. The line will originate in the Slaughter pool, near Sundown, Texas, in the southwest corner of Hockley County, and will terminate in the vicinity of Drumright, Oklahoma.

Only one pumping station will be needed to operate the line at 54,000-bbl.-a-day capacity, but other stations to be installed as needed will boost the capacity of the line to more than 100,000 bbl. daily. Oil delivered to the Drumright end of the pipe line will be pumped into working tanks, from which it can then be transferred to any of a number of existing trunk systems supplying crude oil to various refining centers.

Stanolind has indicated that it probably will dispatch the bulk of the line's daily delivery to its Whiting, Indiana, refinery through the present Stanolind Pipe Line Company system, which extends from South Texas to Whiting via Drumright. The crude oil not shipped to Whiting will be made available to other pipe-line systems operating through Drumright.

◆

Immediate construction of a new pipe line to insure adequate natural gas supplies next winter for the Mid-Continent area bounded roughly by Wichita, Kansas, Kansas City, and Springfield, Missouri, has been announced by J. A. Krug, director, Office of War Utilities. The 26-in. line will extend from the center of Texas County, Oklahoma, 240 miles eastward to the Cities Service Company's connection at Blackwell, Oklahoma.

Cities Service will build the line, as it is the principal natural gas distributor in the area and the one most in need of additional supplies. Neighboring systems, however, are assured of the opportunity to obtain deliveries from the line to assist in meeting any possible deficiencies during the war period and for a year thereafter.

Construction of the new pipe line is necessary, Krug said, because of the vast increase in war manufacturing in the area, with a consequent increase in natural gas consumption, and the decline in output of a number of gas fields upon which Cities Service has depended heretofore.

The new line will deliver up to 140,000,000 cu. ft. of natural gas daily from the rich Hugoton field in Oklahoma and Kansas, which will more than replace the West Cement field, Oklahoma, closed to natural gas withdrawals on May 18. This closing was ordered by the Oklahoma Corporation Commission at the request of the Petroleum Administrator for War to protect petroleum production in the field. Cities Service had been taking upward of 80,000,000 cu. ft. daily from this field.

Preference ratings were issued subject to the company's obtaining any necessary approval from the Federal Power Commission and other interested regulatory bodies, and proceeding under the direction of the Petroleum Administrator for War in regard to drilling of wells and construction of gathering lines in the Hugoton field.

An estimated 55,000 tons of steel will be required to complete the line, which should be ready for operation in December of this year. This is the largest of the three natural gas pipe lines approved by the Office of War Utilities this year. Others are a 120-mile line from a connection south of Toledo, Ohio, to a point south of Cleveland, designed to relieve deficiencies in the Appalachian area, and looping of the Panhandle Eastern Pipe Line, which runs from the Hugoton field to Detroit.

At the request of Cities Service, the preference rating certificate was issued by the War Production Board to the Cities Service Transportation and Chemical Company, which will build the line.

◆

Steel barges for transporting crude oil and petroleum products to the East will be constructed immediately, it was announced by the Office of Defense Transportation. The order calls for a fleet of 168 all-steel petroleum tank barges with a total carrying capacity of 1,600,000 bbl. for operation on the Mississippi and Ohio rivers.

The program announced last December called for wooden barges, part of which the new order will replace. It is expected that the steel boats will be ready for service by late October, when the 21 river towboats that will haul them will be ready for delivery.

Decision to build the steel barges instead of 195 of the 500 wooden units called for in the original program was affected by several factors, ODT stated. A shift in emphasis to light oils as barge cargo made completion of the large number of wooden barges impractical as only heavy residual fuel oil can be moved safely in this type boat. The all-purpose steel barges will be able to move any petroleum products offered; they are able to navigate the upper Ohio River, and they operate much more efficiently than the wooden boats.

◆

Blasting was begun recently in the Millstone River, New Jersey, in the final stages of the pipe-line construction on the "Big Inch" from Texas. This river and the Raritan River are being prepared for the oil pipe line heading for the East Coast.

After the underwater sections are laid, land construction will be completed to Rahway, where the 24-in. pipe line will branch off to refineries in Rahway, Linden, and Elizabeth, New Jersey, and Staten Island, New York.

Work was said to be difficult through New Jersey because of weather conditions and the condition of the ground, which was muddy over a rock foundation.

◆

Portable pipe lines to carry gasoline supplies to motorized units in the field have been developed by the Army. The new pipe line comes in self-contained half-mile units, each complete with a centrifugal pump driven by a 20-hp. gasoline engine, and can be moved by cargo trucks and used independently of any other units.

The sections, alone or in combinations, are said to be able to deliver gasoline through swamps and forests or over mountains at a rate of approximately 200 gal. per min. The pipe can also be used to assist or to replace floating gasoline tanks for ship-to-shore operations.

THE Petroleum Engineer

JUNE, 1943

Hillside Blowout Necessitates Ingenious Repair Method

☆ Definite source of trouble determined by thermal logging—Hole in casing repaired by squeeze cementing through perforations

PETROLEUM ENGINEER Exclusive Feature

by Clarence R. Dale

CAREFUL analysis of a very difficult problem by engineering personnel, combined with the use of modern subsurface instruments and equipment enabled the Shell Oil Company, Inc., to determine the source of a blowout on a hillside among several producing wells in the Ventura field, California. The blowout occurred on a highly developed lease and could have been caused by any one of several wells or by nature itself. The problem was first to determine definitely which well, if any, was providing the conduit for the flow of fluid and to find the source of the trouble within that well, and finally, to devise a method of repairing the well.

The topography of the Ventura field is rugged, consisting mainly of steep hills separated by canyons. The surface elevations of the wells vary over several hundred feet. One morning in the early part of February, water began flowing from the side of a hill above one of Shell's lease roads that had been built through one of the canyons. The water was followed by mud, gas, and muddy, salty water with considerable sand and a trace of oil. A crater formed and in less than 24 hours it was approximately 10 ft. in diameter. By the time the flow of fluid was shut off this crater had reached a diameter of 50 ft. The exposure at the crater definitely had the appearance of a fault zone.

CLARENCE R. DALE

entered the oil business with the Union Oil Company in 1920—Directly connected with drilling and production until 1928, he then began development of instruments and tools for use in the oil industry, including early surveying instruments—Among his developments is the photoelectric method—He has worked in most of the oil fields in the United States—At the present time Dale is serving as consulting engineer for Technical Oil Tools Company—He is also manager of the Inglewood plant of the Technical Products Company, a different organization, whose total production is aircraft parts.

The flow gradually increased until it reached a maximum of about 10,000 bbl. per day and varied between this rate and 5000 bbl. per day until shut off. Virtually all the flow was a frothy fluid of medium brown color. The temperature at the mouth of the crater averaged 100°F. The flow was by surges coming at about five-minute intervals.

Shell immediately began work on the construction of a large sump, about 600 ft. distant from the crater, for storage of the fluid. Meanwhile, the fluid flowing from the crater was pumped to the sump of a nearby well and was disposed of temporarily from there.

An examination of the electrical logs of the wells surrounding the crater disclosed the presence of a shallow, south-dipping fault of approximately 300 ft. displacement, which in its up-dip projection would outcrop in the floor of the canyon below where the blowout occurred. There appeared to be some disturbance of the formations at the

depths of the surface strings in some of the wells, which indicated that this fault may have occurred shortly above the cementing points. In view of the mud and gas flowing from the crater, it appeared reasonable that the flow was caused by a faulty well and that it came from fairly deep sands, passed up the annulus between the water string and the wall of the hole, and along the fault plane to the surface. Later information, however, disclosed that gas from within the casing in the offending well had passed from a hole in the pipe and forced the water borne by the formations behind the primary water string out along the fault plane to the side of the hill.

Attempts were first made to determine which of Shell's wells was the offender by pumping in water and mud between the surface and water strings of the surrounding wells. Water colored with Quebracho was used in some cases and hourly samples of the fluid produced at the crater were taken. Although slight changes of salinity were noted at times, no significant results were observed in the effort to change the fluid by pumping in mud or water. The chloride content and the mud and sand content remained about the same.

As the crater was on the side of a steep hill, it was difficult either to break down its sides or to get tubing into it. The crater was, however, working and breaking farther back into the hill. A 1-in. pipe was run into the cavity for 70 ft. and it was concluded from this that the channel dipped approximately 20° due south. Later, 2-in. tubing was run in for 90 ft. and ⅞-in. rods were run through the tubing to 150 ft. below the fluid level.

Pressure observations were made at the various wells both with the wells shut in and while pumping in mud or water. These pressure measurements gave some interesting information on Well 116, located more than 1000 ft. from the crater, which eventually proved to be the offending well. The static pressure taken four hours after this well was shut in showed a formation pressure of 1700 lb. per sq. in. at 7515 ft.—a pressure much lower than expected. On the following day (after being shut in for 22 hours) the pressure at 7515 ft. was 1685 lb. per sq. in., or nearly the same as for the day before. A third pressure survey was made after the well had been shut in 46 hours and the pressure at 7515 ft. was found to be 1670 lb. per sq. in., or 15 lb. per sq. in. lower than the pressure measured 24 hours previously. Two readings were taken below the bottom of the tubing and failed to indicate a static fluid gradient.

Thermal Logging of Well

To determine definitely the source of the trouble, Shell took thermal logs of the wells surrounding the crater, beginning with Well 116 in which the pressures had been found lower than expected. The thermal logs in all the wells except Well 116 showed no break in the thermal gradient. In Well 116, however, the survey showed the temperature at 1150 ft. to be 16° higher than the normal gradient and indicated a flow of warm fluid on the outside of the water string from a depth of about 2500 ft. up to that point. The graph of the survey and the subsurface conditions of the well are shown in Figs. 1 and 2.

The temperature surveys of the wells were made with a Totco-Dale instrument, which gives a continuous recording of separate classes of precision measurements such as temperature, pressure, and electrical variations. The instrument was run through the 2½-in. tubing, which was bottomed at 7442 ft. in

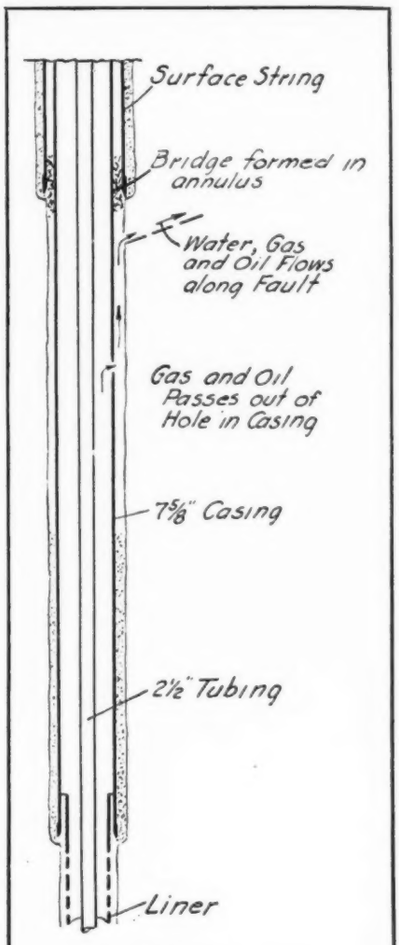


Fig. 1. Subsurface condition of Well 116

A flow that became as great as 10,000 bbl. per day came from the hillside

Maximum diameter of the crater became 50 ft. before the fluid was shut off

Well 116, and the temperature thus had to be measured through both the tubing and the 7⅝-in. casing that had been cemented at 6581 ft.

The thermal recording instrument[1] consists of a fluid-tight cylinder, which is run into the well on a wire line. It records on a moving film a continuous record of the temperatures in the well as the instrument moves down the hole at a controlled speed. The film is developed and placed in a recorder in which the scale is enlarged 40 times and the temperature traverse automatically reproduced at 4° to the inch and to whatever depth scale is desired.

Repair Work

Having determined which was the offending well, an attempt was made to pump fluid between the 11¾-in. water string and the 7⅝-in. casing, but without success, even with the pressure built up to 900 lb. per sq. in. A compressor was then hooked up and gas was pumped downward between the tubing and casing at a pressure of 1300 lb. per sq. in. and at a rate of 1500 M. cu. ft. per day. An increase of only 50 lb. per sq. in. was noted on the casing as a result of this gas input. Gas mixed with Calodorant and Ethyl Mercaptan was then pumped in at the same pressure and rate. After pumping this mixture for a little more than 24 hours the odor of Mercaptan was distinctly noticeable at the crater.

With this additional proof that Well 116 was the cause of the blowout Shell decided to kill the well preparatory to beginning repair work. While maintaining a pressure of 1000 lb. per sq. in. on the casing, 63 lb. per cu. ft. Aquagel mud was pumped down the tubing. It had been estimated that 1500 cu. ft. of mud would fill the tubing and casing but it was not until 2100 cu. ft. had been pumped in that returns were received at the surface. The first returns after the gas was bled off consisted of approximately 10 bbl. of oil and then gassy mud. When the well was completely dead, Ventura mud was pumped slowly between the casing and tubing at a pressure of 500 lb. per sq. in. No returns of mud at the crater were observed. The flow of fluid at the crater ceased when the well was first killed.

After considerable difficulty the tubing was pulled, but when 1600 ft. of the string was out of the hole, the well began flowing. After shutting in and re-killing with water, the rest of the tubing was pulled and a shiny spot discovered at 4322 ft.

As it was now believed that there was a hole in the casing, it was decided to locate the hole with a c. p. (cementing through perforations) cementer[2] and then squeeze cement in the hole in order to repair the well for production. To make certain that the leak did not occur at the worn spot indicated at 4322 ft. on the tubing, the testing was begun at 4514 ft. After testing from 4514 ft. to 4154 ft. and finding no hole in the casing, the c. p. cementer was set at 4331 ft. and mud pumped away between the casing and the tubing (on which the cementer was operated) at a pressure of 200 lb. per sq. in. This indicated the hole was in the casing above 4331 ft. The testing was therefore continued up the casing and the hole was finally located at 2470 ft.

Upon finding the hole, 250 bbl. of 90-lb. mud were pumped in at a pressure of 600 lb. per sq. in. and a rate of 150 bbl. per hour. After leaving the well shut in for three days, 1000 bbl. of 80-lb. mud were pumped through the hole at a rate of 180 bbl. per hour. The c. p. cementer was then set to squeeze cement into the formation behind the pipe through the hole in the casing.

The first batch of cement consisted of 1000 sacks, which was displaced at pressures from 400 to 1000 lb. per sq. in. Only 20 sacks were washed back. While pumping back cement, full circulation was maintained for one-half hour and partial circulation for 2½ hours. The next batch, put in the following day, consisted of 500 sacks of cement mixed with 15 lb. of Jel Flake. This was pumped in at pressures ranging from 0 to 500 lb. per sq. in., depending on the speed of the pump. From 50 to 75 sacks of cement were circulated back and circulation was lost after the first 30 minutes of back

[1] A description of the instrument and its general application is given in a paper, "Thermal Logging of Oil Well," read by Clarence R. Dale before the Spring Meeting of the Pacific Coast District A.P.I., March, 1942.

[2] See discussion of cementers described in article beginning on page 46 of April issue of *The Petroleum Engineer*.

TABLE I

	Before	*After*
Gross	132 bbl. per day	360 bbl. per day
Clean oil	131 bbl. per day	344 bbl. per day
Cut	0.6 percent	4.4 percent*
Tubing pressure	1000 lb. per sq. in.	1025 lb. per sq. in.
Casing pressure	1600 lb. per sq. in.	1325 lb. per sq. in.
Gas	728 M. cu. ft.	490 M. cu. ft.
Orifice	12/64 in.	20/64 in.

*The cut later cleaned up to 0.1 percent.

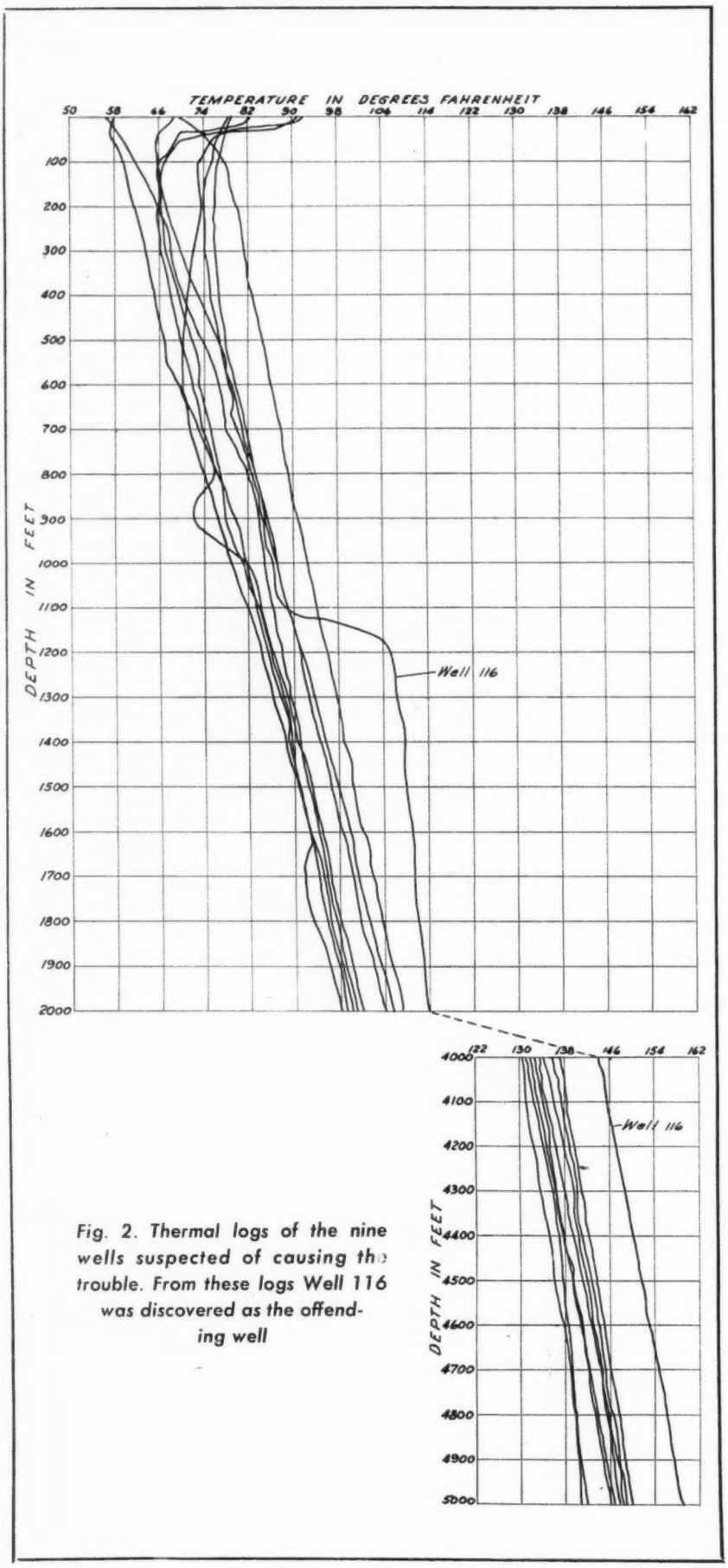


Fig. 2. Thermal logs of the nine wells suspected of causing the trouble. From these logs Well 116 was discovered as the offending well

scuttling. Circulation was recovered with water. The final batch of cement pumped in the following day consisted of 125 sacks of cement mixed with Aquagel and Jel Flake. This was displaced with 100 cu. ft. of water. A pressure of 350 lb. per sq. in. was held for 10 minutes before washing back and only a trace of cement showed in the returns.

After standing cemented for 8 hours, a pressure of 2500 lb. per sq. in. was held on the casing for 30 minutes without loss of fluid. A water shut off test was made the following day, which satisfied Shell that the job had been completed satisfactorily. The well was then flanged-up and the mud circulated out with water. Connections were made and the well began flowing on compressor. Shell's practice of completing these wells with one string of casing was a fortunate circumstance in this repair operation. Had there been more strings, it would have been considerably more difficult to locate the source of the trouble and it probably would have been necessary to cut and pull pipe before the flow at the surface could have been stopped.

The productions before and after the blowout occurred and the well was repaired are shown in Table 1.

☆ ☆ ☆

Carbon Black Production

The carbon black industry experienced reverses in 1942, according to data reported to the U. S. Bureau of Mines. Production was 3 percent below the record of 1941 and sales declined 30 percent. Anticipating a rise in price, which occurred in January, 1942, consumers replenished their stocks at the end of 1941. Curtailments in exports and in rubber manufacture contributed toward a decrease in demand that was not offset by increased uses for military and for miscellaneous purposes.

Stocks held by producers at the end of 1942 were 242,755,000 lb., the highest level since 1932, when 257,998,000 lb. were reported, and more than double the 118,847,000 lb. in stock at the end of 1941.

Natural gas burned in the manufacture of the 574,006,000 lb. of carbon black produced in 1942 amounted to 335,533,000,000 cu. ft., 8 percent less than was used in 1941. Carbon black producers paid an average of 1.29 cents per 1000 cu. ft. of gas in 1942 compared with 1.13 in 1941.

The average value at the plants of carbon black in 1942 was 3.41 cents a lb. compared with 3.26 cents in 1941. This is the highest average since 1937 when the same rate was recorded.

Whither Are We Bound?

PETROLEUM ENGINEER Exclusive Feature

☆ A discussion of the refining processes of the future and how the change in utilization of petroleum products will influence future manufacturing procedures

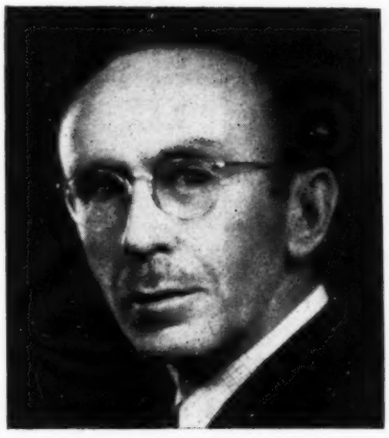
PART 1

by R. G. Lovell

Development Engineer, Hancock Oil Company of California

WHITHER are we bound? Every man engaged in any capacity in any branch of the petroleum industry is asking this question. The query is pertinent and there is an answer; but there is definitely not any one answer that fits any great number of cases. The solution cannot be general; it must be specific and will not, therefore, be found by study of statistics of crude oil production or of past demands for its products. The knowledge that the per capita wealth of the United States is several hundred dollars offers little solace to the man without a cent; nor does it help to solve the problems of an oil company with large resources of capital and raw materials. General averages indicate trends and make striking graphs but are not legal tender. The form of the question, therefore, should be changed to: "Whither am *I* bound?"

To doubt that marked changes are to come when our national and international economy is no longer based upon military necessity is only wishful thinking and no time shall be wasted in discussion of so fallacious a thought. On the other hand, any discussion having as its objective the determination of the shape of things to come must, necessarily, include a survey of things that have gone and this retrospective view must be kept clear of our natural tendency to gloss over the errors of the past. To err is human but to recognize the error as such without regret and to avoid repeating the mistake is just plain, sound sense. It will further clarify our analysis to recognize that some of our errors have been forced upon us by commercial necessity and were not the result of lack of technological information. Everyone is familiar with the fiction, current for years, to the effect that many improvements aimed at increasing the efficiency of internal-combustion engines have been developed and patented but that the patent rights had been bought up by oil interests and kept off the market with the idea of maintaining sales volume of petroleum products. This tale has never had any foundation in fact simply because there is no sense to the idea. The room for improvement in the efficiency of an automotive internal-combustion engine is liberal—the average overall efficiency of our automobile is about 8 percent —which has stimulated research for methods of improving both the fuel and the apparatus that turns it into power.



R. G. LOVELL

received his academic training in New York and declares that he has spent the 40 years since leaving college in intimate contact with the application of the principles of science—In this article, as well as in the ones to follow, the author endeavors to apply these principles to his observations of many years of the changes that have taken place in the utilization of petroleum products—It is with some trepidation that he reaches certain conclusions regarding the probable future forms of utilization and how these are likely to affect refining procedures.

Many of the proposed improvements in the engine and/or its auxiliaries effected efficiencies that seemed, at first glance, to be marvelous and were confidently expected—by the inventors—to revolutionize the entire petroleum and automotive industries. Upon investigation, however, most of these so-called revolutionary ideas called for an amount of auxiliary apparatus that nullified their theoretical advantage, whereas others demanded changes in design and construction the cost of which consumed the monetary advantage of the fuel saving for long periods of time. In short, most of these "ideas" failed to work out because their promoters were blind to the obvious fact that American industrial economy is based upon quantity production and that an invention, to be successful, must be able to overcome the advantages that come from this mass production. They further failed to realize that most successful inventions are the children of necessity. Our supplies of petroleum have been so prolific that the need for high efficiency in its use has not been so pertinent as in other less favored countries. If necessity, then, was the mother of some of these inventions, it might be well to look around for the parents of necessity. They were speed and power.

From the very beginning automobile manufacturers were constantly called upon to supply cars and trucks that would go faster, carry heavier loads, and ride more comfortably. For a time these demands created no problems difficult of solution. All that was required was a larger engine with better balanced moving parts and larger intake manifold and valve areas. But this had to come to an end somewhere for at each increase in engine size and weight, more weight of chassis was required, the propulsion of which called for still more power and weight of engine and so on.

History of Engine Knock

The significance of the 4 to 1 pressure ratio between the burning air-gasoline mixture and the mixture at top of stroke before ignition had been understood, naturally, but fear of piston striking cylinder head had deterred the designers from lessening the clearance in order to reach higher compression pressures and the consequent increase in power. Metallurgical science, however, overcame this fear by developing better steels for crankshaft, connecting rods, and wrist pins. When the compression pressures began to rise,

however, another difficulty arose. The engine developed a strange knock that was particularly severe with heavy loads and high speeds; moreover, if the engine was permitted to run under the knocking condition, high heat soon built up. The engine was not the only place where knocking occurred. The anvil chorus of the "I told you so" fraternity went into its traditional act and declared that inertia and metal expansion due to high temperature were combining to cause the pistons to strike heads and that the limit in close clearance had been exceeded.

Fortunately, there were a few sturdy souls who refused to accept this theory —perhaps because the knocking had a different sound from that usually associated with metal striking metal and increased in severity with increase in volume of gas admitted. This greater volume would, of course, have a dampening effect on the blow if it were the result of metal striking metal. Support for the latter idea came from high-speed steam engine practice. Minimum clearances here are desirable for efficiency but entail close attention to providing dry steam and avoiding initial condensation else water knock occurs that can and does cause engine failure. Consideration of this warranted dismissal of the notion that the inexplicable knock in the internal-combustion engine was caused by piston striking head.

How the Cure Was Found

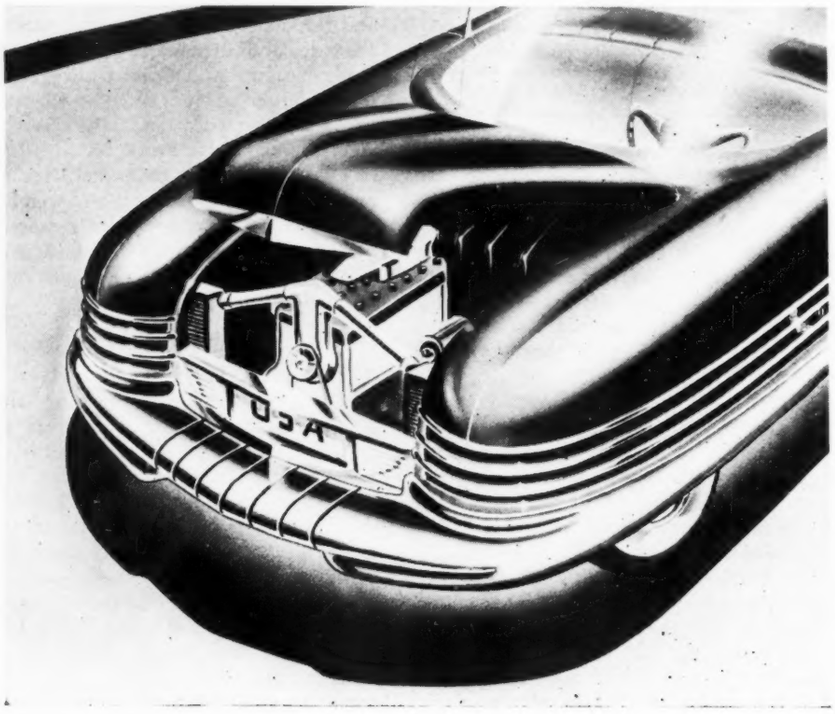
The story of the long period of research to find what did cause the knock is interesting but, as only the result is pertinent to the present discussion, that will be stated as simply as is consistent with logic and clarity. The combustion cycle of the air-gasoline mixture was found to be measurably progressive, not instantaneous. It was further proved that the knock occurred toward the end of the cycle when the lighter elements of the gasoline, with lower ignition temperatures, had burned and the cumulative heat of combustion had raised the temperature in the cylinder to a point where the remainder of the mixture actually exploded, releasing so much pressure that the engine could not absorb it in the form of power in so short a space of time. The snap answer to this was to use only the lighter hydrocarbons but this was obviously impracticable. There remained, then, the task of finding some material to incorporate in the gasoline that would be effective in delaying the combustion of the heavier parts of the fuel just long enough to permit the engine to transform the pressure of their combustion into usable power. The compound known as Ethyl fluid was found to accomplish this more effectively than any other of the many compounds tried.

One of the limits to the use of Ethyl fluid has always been that its unit effectiveness decreased with increase in its concentration in the gasoline. In point of fact this has turned out to be an advantage inasmuch as it exerted a retarding influence on the idea of endeavoring to "lead up" a low-grade gasoline, with an undue proportion of heavy fractions, into a motor fuel of good all-around performance characteristics. It was early discovered that by reducing the proportion of the elements that made advisable the use of Ethyl fluid, not only was a smaller amount of the fluid required to reach a given anti-knock rating, but the general performance of the fuel was improved. Thus the low end boiling point of the better grades of Ethyl gasoline.

Necessity Changes Her Demands

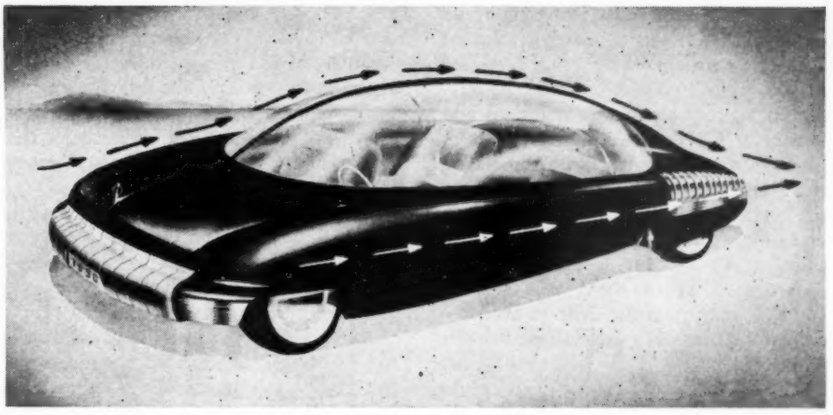
The foregoing has had its effects upon the problem, past and present, and will have its natural effect upon the future. These effects are by no means adverse when viewed in a rational light and it must be remembered that the switch that controls this rational light has three positions—positive, negative, and neutral—with each position having many points, any of which may be used, depending upon the circumstances of the manipulator. We have, heretofore, used commercial necessity many times as an excuse for refraining from making costly changes in our refining procedure, which changes could produce better products; but the buyers of our products would not pay the price necessitated by the cost of these changes. Commercial necessity must, inevitably, remain the dictator, but we hope to show in this article how the dictator is changing his demands and what these demands are likely to be in the future; and to point out some of the steps that can be taken to meet certain selected demands profitably.

A few of these changes have already taken place and to discuss them will add some lumens to the rational light. A number of younger men like to feel that cracking was developed chiefly because cracked gasoline had a higher anti-knock rating than the straight-run product. It is true, of course, that it has a higher anti-knock rating, but at the time cracking was developed there was no demand for a knock-resisting fuel because compression ratios were low. The fact is that the cracking process was, like many other inventions, the child of necessity. The stupendous growth of the automotive industry had created such a demand for gasoline that, although adequate supplies of crude oil were made available by new drilling, the quantity of residuum remaining from the gasoline distillation was greater than the market for the material, as fuel oil, could absorb. Cracking by pyrolysis converted a substantial proportion of this resid-



Artist's conception of an automobile of the future. Opened hood shows engine and twin radiators

(Photo courtesy Ethyl Corporation)



A car of the future with transparent plastic top and designed for minimum air resistance

(Photo courtesy Ethyl Corporation)

uum, both the heavy bottoms and the heavier distillate fractions, into a synthetic product within the boiling range of gasoline, and the situation was eased.

It was about this time that the automobile people began to prod us for gasoline that would operate in their higher compression engines without that disagreeable knocking. The new synthetic product was found to be a distinct improvement over the straight-run stock in this respect but offered difficulty in chemical treatment for reduction of sulphur and other impurities. A blend with the straight-run stock in proportions was found to be satisfactory, however; but it definitely will *not* be suitable for the engines of tomorrow. This does not offer grounds for fear of the future because the means for meeting the demands for the superior fuel are already developing and will be discussed later.

A new problem then came along to keep hard working oil men from their rest. This was a prejudice among fuel oil users against the cracked residuum. Naturally, the cracked residuum was higher in specific gravity than the straight-run bottoms and our earlier efforts to "cut back" with the heavy distillate in the usual way left the blender with a troublesome sludge that clogged heaters, lines, and burners. The sludging was corrected by a change in blending procedure but much of the prejudice remained. Finally, after some years of continuous effort, we were able to convince the users of the seemingly obvious truth that, as they bought their fuel by unit of volume and used it by unit of weight, the heavier fuel gave them more heat units per dollar.

In order to realize this saving, however, better heating facilities were required. Land conditions are usually such that provision of these heating arrangements offers few difficulties, but in marine service the problem is not so easy. Fresh water for boiler feed is not readily available and the main power units are, necessarily, operated condensing, leaving no exhaust steam available for heating the fuel to increase its pumpability; nor can live steam be used for atomizing at the burners for the same reason. This last is no negligible amount, running as it does from 2 to 3 percent of the total steam output of the boiler.

All these factors brought about the general use of the mechanical system of burning fuel oil in marine service. In this system live steam is used that heats the oil by surface contact to a relatively high temperature with a moderately elevated pressure, the steam condensate returning to boiler feed. When the oil thus heated is released to furnace pressure and temperature and given opportunity for intimate mixture with preheated air the combustion is fairly efficient. At any rate, whatever the deficiencies of the system were, marine engineers had become accustomed to them and were satisfied with a fuel oil of about 11° or 12° A.P.I. and a Furol viscosity of approximately 75 sec. at 122 deg.

Military Necessity Takes a Hand

Certain details of the mechanical equipment of the vessels of our Allies called for the delivery to them of a fuel of much lower viscosity than this. Naturally, many discussions arose over the efficiency of a liquid fuel of a density as low as that indicated by a viscosity of 25 sec. at the standard temperature. Our theory was fundamentally perfect but in practice the low viscosity fuel had markedly faster steaming characteristics and its efficiency under normal and overload conditions turned out to be equal to the heavy oil in terms of pounds of steam per volume unit of fuel. This served to establish the low viscosity fuel oil and, as we were required to supply it, various methods were found to do so without any particular disturbance to our regular refining practice—the only disturbance being that to our ego. Sound reasons exist for this seeming reversal of rule but they are not pertinent to the objectives of this discussion. The reader is asked simply to keep in mind the points made in order that he may be able readily to apply them at a later time when we shall endeavor to paint a harmonious word picture of the refinery of the future.

Background for the Future

This word picture is not intended to be especially instructive technically. The writer confesses, or rather is confident, that our automotive research men are years beyond him in their work; his entire objective is to interpret and give significance to the things that these men have already developed, and to indicate by reasoning-based-on-experience the lines that present research is following and the lines that are likely to be followed in the future. We shall keep both feet on the ground else fanciful flight lead us to a fall in a less comfortable position. No hint of revolution in practice is to be suggested; rather the advances to be indicated are purely evolutional and are to come largely by reason of relief from the strictures of commercial necessity that have retarded our progress for too long. To forecast avenues of research without offering a reasonably clear view of the targets would fail to interest the oil man simply because such procedure is senseless and offers nothing constructive.

Unquestionably, the science of aviation — not the aviation industry — pointed the way to better fuels for the carburetted engine. But to point the way was not enough. We have made, in required quantities, a gasoline meeting aviation specifications for several years but the market for it was only a fraction of the motor gasoline demand.

Despite the fact that the base stock in the alkylated aviation gasoline was made from raw gaseous stocks that were largely by-products of normal refinery operations, the high cost of the processing apparatus, the expense of the liquid catalyst used, and the limited market made the plant not a particularly attractive proposition for any except the largest refineries. Then came a necessity for increased production with which there could be no argument. Economics were forgotten. The whip lash of war spurred us to investigate everything that seemed reasonable and much that did not so seem. It was found that by increasing the allowable TEL concentration we could meet the specification of 100 ON aviation gasoline with about 50 percent of selected

alkylate, the remainder being made up of *iso*pentane and a narrow cut of straight-run gasoline from selected crudes. This, in itself, doubled the output in sections where the crude oil was available. Catalytic cracking has also played an important part in meeting the emergency and, in the opinion of the writer, will continue to occupy a place of increasing importance as time goes on. In fact, it is his considered judgment that catalysis will be the key that will open the door to the successful synthesis of nearly all petroleum products.

Motor Vehicle of the Future

The imagination of an H. G. Wells or a Jules Verne is neither required nor desired in order to see something of the shape of things to come in the automotive demands for petroleum products. The stark inefficiency of some 25,000,000 passenger motor vehicles, many of them transporting but one person and weighing 3000 to 4000 lb. each, running over our streets and highways, is not pleasant to contemplate but nonetheless true. Nor is the picture improved when it is realized that not more than 10 percent of the potential power in the fuel is being converted into power to propel the vehicle. To excuse this condition by the simple, but ambiguous and buck-passing expression, "commercial necessity," is not very convincing. An explanation is very much in order. Not the least of the reasons for this inexcusable state of affairs were "keeping up with the Joneses" and the fact that our general prosperity had made it possible to take full advantage of both the joys and the utility of automotive transportation. Having designed our cars for style and comfort and having built some 85,000,000 of them it was not so easy to change standards simply because their efficiency was low. Efficiency gets little consideration from a man with a pocket full of money and plenty of gasoline on every street corner. So let's have a look at the set of conditions that is expected to rationalize this admittedly wrong setup.

One of the chief factors that has retarded substantial progress in engine and body design has always been the enormous existing investment in factory machine tools that would be largely useless for building the new cars. Let no person delude himself that these impending changes are to be of the order of magnitude of the yearly changes that we have seen in the past. Nothing of the kind. Our present engines weigh about 6 lb. per hp. and the average car weighs, say, 3800 lb. and requires more than 100 hp. to propel it at the speed demanded. We have, therefore, such a weight and size of power plant that we must place it at the opposite end of the car from its work. Further, the present engine must dissipate about one-third of the fuel it consumes in cooling the relatively large areas exposed to the gases of combustion. To build up our picture of the automobile of tomorrow we can start with two major assumptions:

First, the automotive manufacturers, realizing the potentialities of the situation but conscious also of the commercial limitations, have ready designs for the improved engines and chassis.

Second, there will be the usual number of "bugs" in most of these designs but the period of retooling—a year at least—will give time to iron them out.

The bugs are bound to be numerous but, as the principles will have been well worked out beforehand, they are not likely to be dismaying or especially retarding. The conquering of each bug inevitably points up additional improvements not before given consideration.

As we are not predicting the millenium we cannot base our predictions on the hope that all designers are going to follow the same avenues or are going to come up with the same type of engine. In fact, upon thinking out all obvious implications, one is justified in the belief that there will be an increase in number of types of power plants most of which will remain simply because their designers will have had the courage and foresight to analyze clearly *all* of the implications and incorporate the results of their analyses in their work. Some of the designs will, of course, become casualties of progress, not because the designer had thought too far ahead but because his vision had been myopic. The writer will present his list of general types, not with the idea that it is all-inclusive nor that all of them will survive. He will, however, endeavor to justify each type and allocate to it the class of duty for which he feels it is best suited.

Consideration to Side Issues

Not a man who reads this article is completely free from the "yeah-but" habit. The "yeah-but" addict reads a tale wherein the author presumes to look into the future and draw some pictures of what he sees and immediately the critical reader spots what he believes to be some holes in the background of the picture. His natural and quick conclusion is that the author is simply giving his imagination some exercise without having any very clear idea of the implications of his pictures nor how they can be tied together to make a harmonious mural. Before making my predictions, therefore, this writer shall point out that he has given consideration to as many contributing and limiting factors as seemed at the moment to be pertinent.

The first of these factors will be the conditions under which each type of power plant and vehicle shall be expected to operate. It is no more reasonable to expect to accomplish the things to be pointed out with the present system of public highways and private railways than it would have been to try to operate with our present transportation equipment over the highways and railways of 50 years ago. If any one had proposed, at the turn of the century, that the time was soon to come when individuals would be traveling the highways at a speed of a mile per minute and faster, such a person would have been classified as mentally deficient. And for any person, at that time, to have predicted air-borne transportation would have removed him from the classification of mentally deficient and demoted him to the clearly insane group.

With the hope of forestalling some number of the "yeah-buts," therefore, we shall interject at this point our analysis of the highways and railways of the future, based upon the potentialities of the hypothetical vehicles we are proposing. If we do this for the "yeah-butter" something must also be done to curb the over-vitaminized imagination that, unless kept under control, might result in the conclusion that, judging from advances being made in aviation, we might not have any future use for either highways or railways. The writer submits that there never have been any revolutions in science that caused any revolutionary changes in our affairs. All scientific changes are purely evolutionary and their effects are to change our regular methods in a greater or lesser degree or with varying rapidity, but no one of these effects is ever revolutionary. As improvements in gasoline engines have been made that called for improvement in fuel or lubricants, ways have always been found to manufacture these improved products. When the combined effect was great enough to demand improvements in highways, in order that full advantage could be taken of the improved machines, such improvements have been made and taken in stride. All this has been gradually progressive; so gradual in fact that we have been unaware of the changes, like the physical changes that take place in a human being, which are not noticeable to our close associates because we see them every day. The accumulated effect is noticeable, however, if we have been out of contact for some time. Ever pick up a magazine of dateline some 20 years back and look at the automobile advertising? Try it some time and you will see what we mean.

(To be continued)

☆ ☆ ☆

P 615.51
P 094.83

Synchronous motors driving reciprocating pumps through a firewall in a gasoline pipe-line station in Iowa

Pipe-Line Problems From the Electrical Viewpoint

PETROLEUM ENGINEER Exclusive Feature

☆ **Careful investigation and analysis vital to success of any pipe-line construction project**

by W. G. Taylor

Petroleum and Chemical Section, Industrial Engineering Department, General Electric Company

NATION-WIDE interest has been created by the construction and rearrangement program for oil and gasoline pipe lines brought about by the necessities of war. Even the doctor, the lawyer, and the merchant, in the 17 eastern states where the oil and gasoline situation has become acute, have learned many things about these great common carriers, the existence of which they scarcely realized before.

On the other hand, those entrusted with the responsibility of developing new projects or revamping old lines are well acquainted with the economics and fundamental design and construction factors, yet in every case the old problems present themselves from new angles and hence require careful investigation and analysis to assure well coördinated results.

Electric Drive

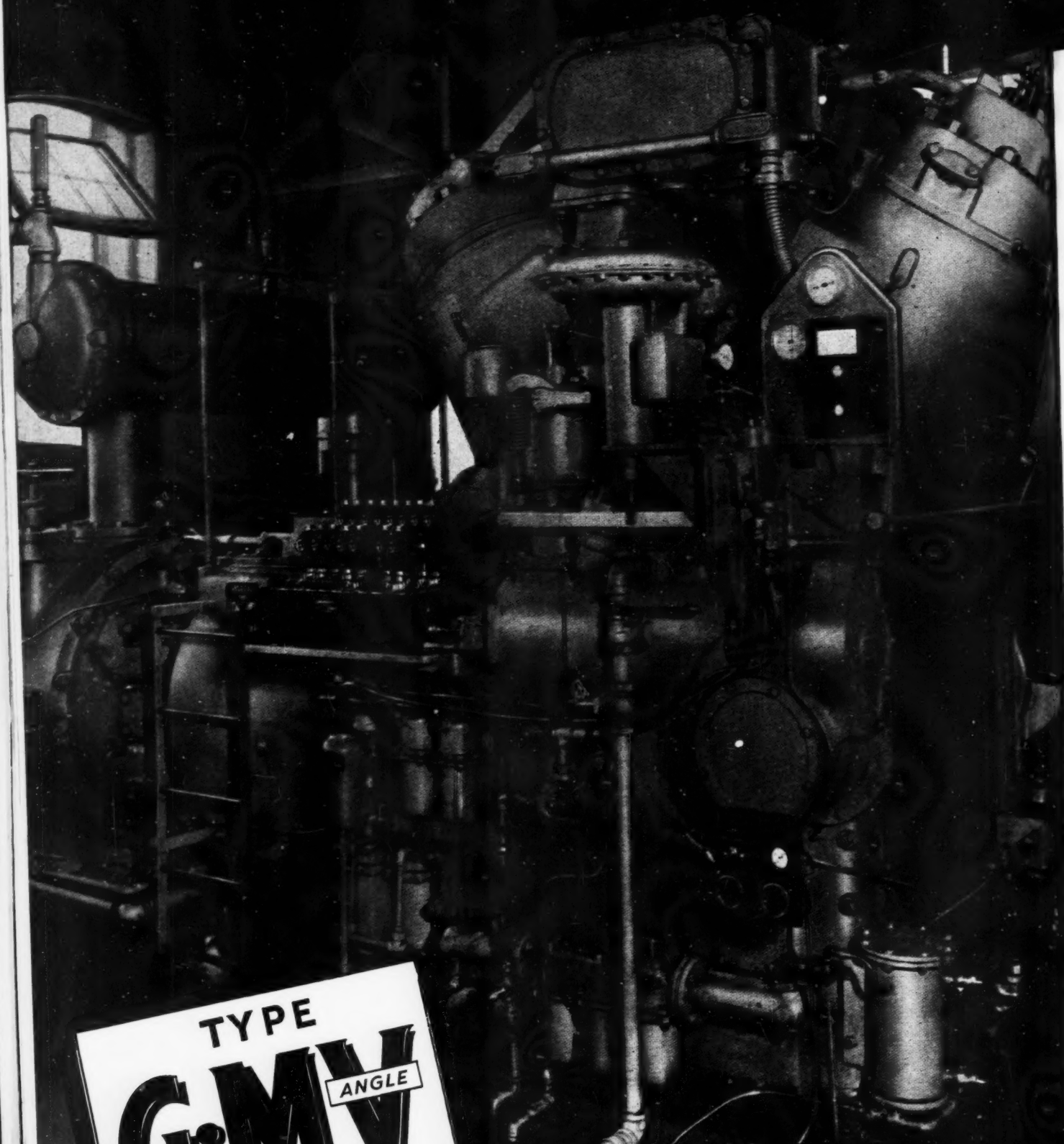
Problems are usually found in the selection and coördination of mechanical and electrical equipment. In any new pipe-line project, it must first be decided whether the pump drive shall be electrical or mechanical. Under war conditions, the selection of electric drive is practically inevitable because of its relative availability and use of less of the scarce materials. The manufacturing facilities for other types of pump drive are loaded to capacity for months or even years in advance by the requirements of many important programs, especially that of shipbuilding.

(Continued on Page 44)

W. G. TAYLOR

has been an industrial application engineer with the General Electric Company for many years, specializing since 1911 in the oil industry in its production, pipe-line, and refining branches, and identified with most of its major electrical problems and developments—A native of New York State, he graduated from Cornell University in 1907 as a mechanical and electrical engineer, with previous mechanical training in machine and locomotive repair shops—After taking the General Electric test training course, he served for several months as assistant engineer of distribution in the New York and Queens Electric Light and Power Company at Long Island City, New York, and then returned to General Electric—He is licensed as an engineer by the State of New York.

THERE GOES A LESSON O



TYPE GMV ANGLE

Compressor

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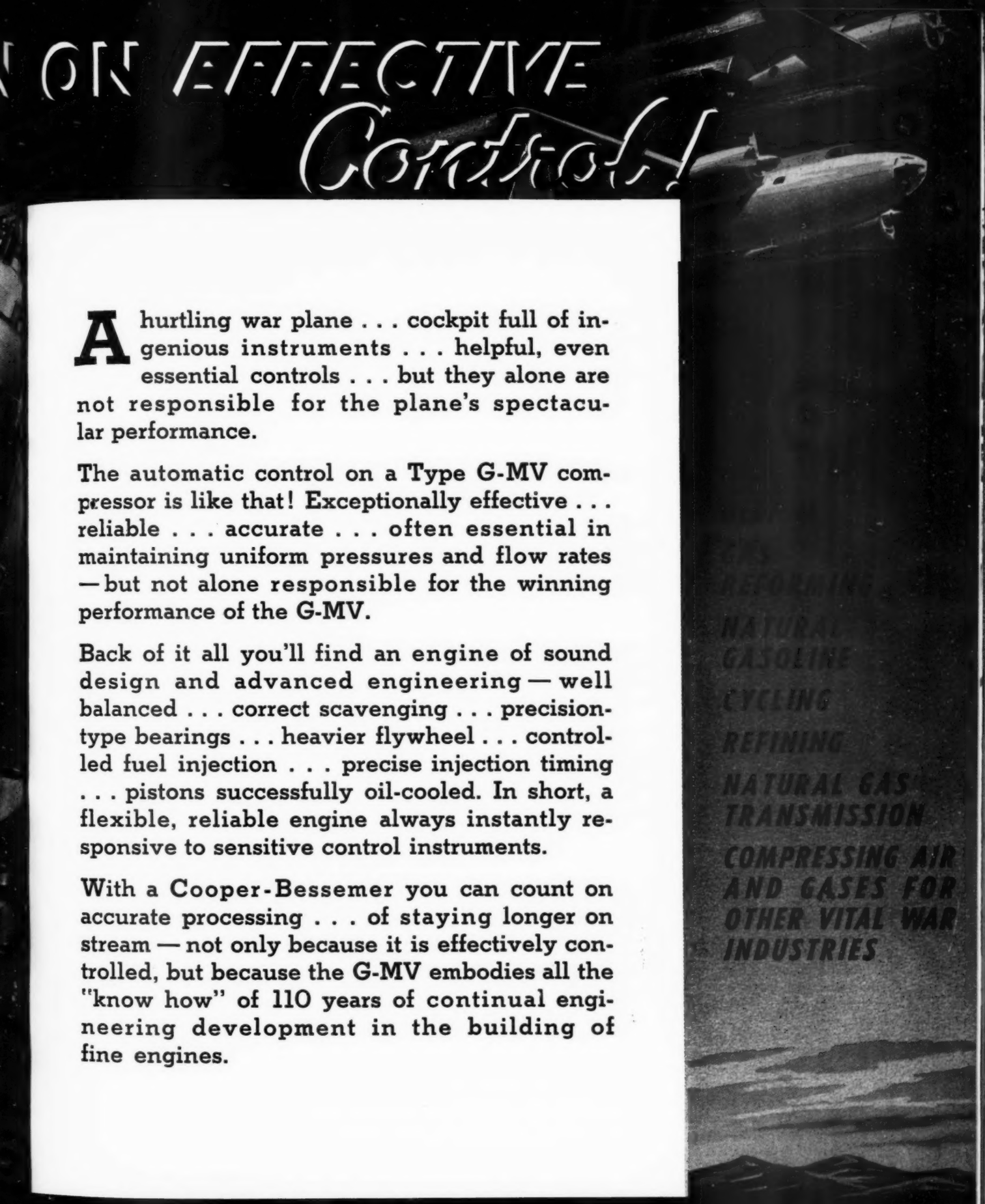
ON EFFECTIVE Control!

A hurtling war plane . . . cockpit full of ingenious instruments . . . helpful, even essential controls . . . but they alone are not responsible for the plane's spectacular performance.

The automatic control on a Type G-MV compressor is like that! Exceptionally effective . . . reliable . . . accurate . . . often essential in maintaining uniform pressures and flow rates — but not alone responsible for the winning performance of the G-MV.

Back of it all you'll find an engine of sound design and advanced engineering — well balanced . . . correct scavenging . . . precision-type bearings . . . heavier flywheel . . . controlled fuel injection . . . precise injection timing . . . pistons successfully oil-cooled. In short, a flexible, reliable engine always instantly responsive to sensitive control instruments.

With a Cooper-Bessemer you can count on accurate processing . . . of staying longer on stream — not only because it is effectively controlled, but because the G-MV embodies all the "know how" of 110 years of continual engineering development in the building of fine engines.



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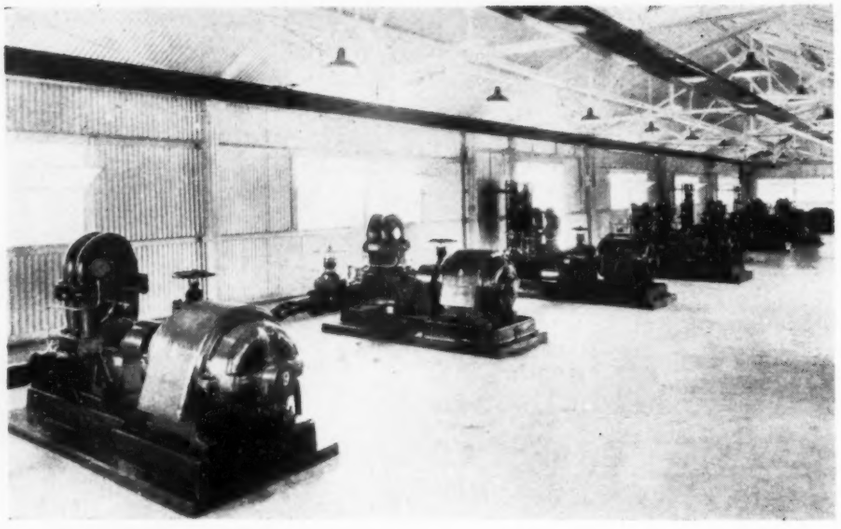

Induction-motor-driven pumps in a crude oil pipe-line pumping station in Texas

(Continued from Page 41)

Although it is true that electric motor production is also under heavy commitments, motors usually can be produced and delivered in the time required to build a new pipe line, provided that very early attention is given to the selection of types and sizes, and that orders carry a fairly high priority classification and are placed promptly. The importance of this is obviously due to the large volume of equipment in production and being ordered under high priorities for many urgent government projects, such as the aviation gasoline and synthetic rubber programs.

It is equally important that motor control equipment also be ordered early, to avoid its becoming a bottleneck in the completion of a pipe-line project. Some types of control equipment are in a much better production situation than others, and this should be checked before it is too late.

The combination of a high-speed centrifugal pipe-line pump direct-connected to an electric motor requires the minimum amount of critical materials, especially steel, and is therefore likely to be a preferred type of installation. A reciprocating pump runs at slower speed and requires a motor of moderate speed, of physically larger size and using more material than a high-speed motor of the same horsepower capacity; it also necessitates reduction gears between the motor and the pump. Gears are in such heavy demand now for marine and similar drives that they are not readily obtainable, but even if they were, the steel required would still militate against their use, despite the fact that for low pumping capacities (usually less than 20,000 bbl. per day) or for high oil viscosities (usually over 400 Seconds Universal Saybolt), the reciprocating pump has decided advantages.

High-speed motor-driven centrifugal pumps for pipe-line service occupy a minimum of floor space, and hence require small pumping stations. The units are comparatively small and light, their installation can be quickly made, and they can be moved to new locations readily. The total investment at each station is comparatively small.

Although the economics of the pumping problem are complex, the factors that should be considered in electric motor drive are: first cost, costs for operating labor, lubricating oil, and maintenance, amount of water required at a station, the effect of altitude on operation, the ease and accuracy with which loads and power consumption can be measured, and the relative reduction in operation cost with decrease in the amount of oil handled by the pipe line. These factors are practically independent of the type of pump used.

Motor Selection

On the assumption that electric motor drive is selected, the next problem is to determine the type and frame construction of the motor to be used. In general, the main motors will be of the constant-speed type, but may be either synchronous or induction motors. The latter are generally used. Not many synchronous motors have been applied to pipe-line pumps, but where they have, it has often been for the purpose of power factor correction to take advantage of power factor clauses in electric power contracts. The combination of an induction motor and a capacitor will accomplish this purpose, however.

Synchronous motors in standard designs are available for lower speeds than induction motors, and for this reason are more applicable to reciprocating pumps. At the high speeds for which centrifugal pumps are designed, the induction motor is usually selected. In the range of hp. capacities and speeds required for main pipe-line service, either type of motor may be the lower in cost and better in characteristics, depending largely on the particular horsepower and speed under consideration; it is consequently necessary to check the relative prices, efficiencies, and power factors to make an intelligent decision. Exceptions to this are cases where 3600 r.p.m. is the speed chosen; for this speed the induction motor has much the lower cost. This is also true in some cases at 1800 r.p.m., but not always. At present, the question of delivery also must be considered, as it is more likely that the induction motor can be obtained in less time.

Although it is true that due to the necessity of an exciter for a synchronous motor, the control equipment will cost a little more than for an induction motor, this matter in most cases is outweighed by other factors involved in the selection of the motor type.

Protection Against Hazardous Conditions

After the type of motor to be used is determined the question of protection against hazardous gases should be considered. It is obvious that this is important for a gasoline pipe line, but for a crude oil line less attention has been given in the past to this problem. It is now recognized, however, by many pipe-line engineers that crude oil contains volatile fractions that will produce hazardous conditions in case of leakage in the pump room. It is the best practice, therefore, to make provision against serious results from such leakage in crude oil pumping stations.

There are two ways to make station operation safer in this respect, one to use explosion-proof motors in the pump room and to locate the electric control equipment in a separate room in which a slightly increased air pressure is maintained, and the other to erect a fire-wall between the pumps and the motors and place the control equipment in the motor room. Explosion-proof motors could not be used for the 24-in. War Emergency Pipeline because they are not available in sizes as large as 1500 hp.; consequently use of a fire-wall was decided upon as the most practicable method of protection. Slow-speed synchronous motors are not available in explosion-proof form, as they are not suitable for such construction insofar as is indicated by present progress in the art of design. Explosion-proof induc-

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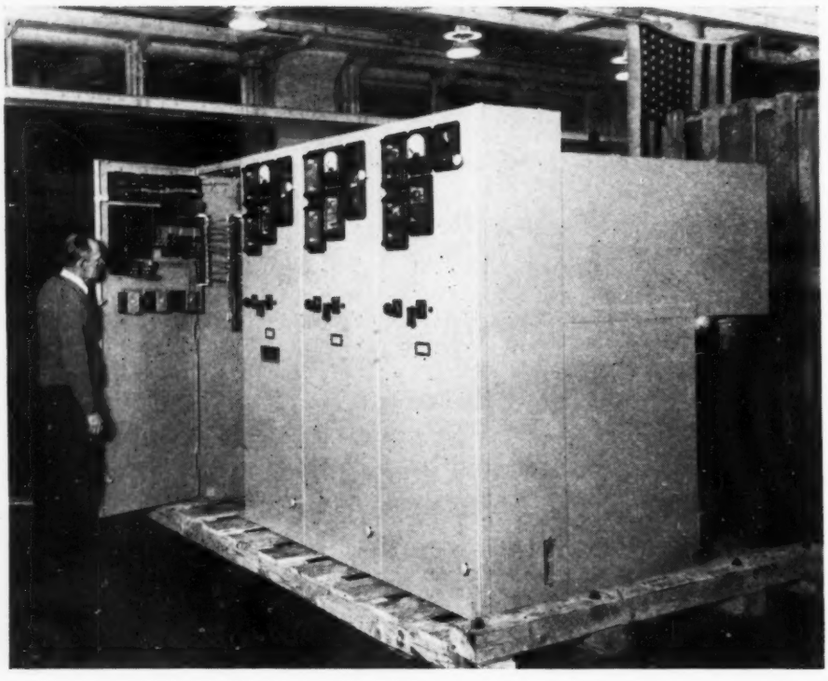

Full-voltage starting equipment for one of the pumping stations on 24-in. War Emergency Pipeline. The incoming line unit is at the left with opened door

tion motors, however, are available and are now listed by Underwriters' Laboratories, Inc., as suitable for Class 1, Group D locations in sizes up to 600 hp., 3600 r.p.m. This listing is evidence to the purchaser that actual explosion tests made by the Underwriters Laboratories at the motor manufacturer's expense have demonstrated that the construction is explosion-proof and adequate for the purpose.

Although large motors for use in hazardous locations may be obtained in the inert-gas-filled design using surface air coolers, the use of open motors and a fire-wall meets most requirements because pipe-line stations do not involve the problem of hazardous gas conditions spread over a wide area as is often the case in oil refineries. The usual source of such conditions in a pumping station is in the pump room or in the manifold area, and if the latter is placed on the leeward side of the station with respect to the prevailing wind, the possibility of gas from this area producing hazardous conditions in the station is considerably reduced.

Co-ordination

From the electrical viewpoint, a pipe-line pumping station is a relatively simple installation, involving a few motors to drive the pumps, with suitable motor control equipment, transformers for the power supply, and protective equipment for overloads and undervoltage, high and low hydraulic pressures, lightning disturbances, etc. The problems lie in the proper selection and coördination of all equipment involved, as discussed at some length in a previous article[1], to which may well be added the following further comments.

Motor Starting and Acceleration

A standard squirrel-cage induction motor can readily start a centrifugal pump from rest even at reduced voltage, but there may be a problem of accelerating the pump to full speed in a reasonable time even when the discharge valve is closed. This is due to the fact that at approximately 75 to 80 percent of full speed the torque available from the motor and that required by the pump with the discharge valve closed approach each other more closely than at any other accelerating speed, and conditions may develop that will reduce the margin between them seriously. With units designed for a synchronous speed of 3600 r.p.m., the margin is less than for designs of lower speeds because of the inherent accelerating-torque characteristics of induction motors designed for these speeds. It will be realized readily that the excess of motor torque over the required pump torque at any speed below full speed is all that is available to continue the acceleration to higher speeds. If there is no excess, acceleration will cease and the speed will "stick" at the point where the excess disappears. When the excess is small, the rate of acceleration is slow, and the time required for the unit to reach full speed is correspondingly lengthened.

At full voltage on the motor, however, there is always ample excess torque for acceleration all the way up to full speed at a reasonably fast rate. When the voltage is reduced, either because of drop in the transmission lines, feeders, and transformers, or because of the use of an autotransformer or reactor for starting purposes, or both, it is necessary to be sure that the correspondingly reduced motor torque is still sufficient for successful acceleration. The importance of this is explained by the fact that motor torque is reduced in proportion to at least the square of the voltage, and even more in some motor designs.

Worst Starting Condition

Most pipe-line pumping stations have more than one main pump motor. In such cases, the worst starting condition, so far as the load on the power system is concerned, is created when the last motor is being started and the others are already running at full speed and fully loaded. Under these circumstances, the heaviest current is drawn from the power system, and the maximum voltage drop occurs in the power lines and transformers. In general, the greatest loss in voltage is in the transformers at the pumping station, and this is usually of considerable magnitude. The effect is to leave only a relatively low voltage available at the motor during its accelerating period, which is the same effect accomplished by a reduced-voltage starter of the reactor type. It will be found in many cases, therefore, that the further addition of a reduced-voltage starter will not only be unnecessary, but may reduce the voltage below that which will permit successful motor and pump acceleration. Such a condition calls for motor starting by the full-voltage method, which means that the line voltage available under this heavy load condition is applied directly to the motor terminals. The current drawn from the line by the motor being started is proportional to the voltage actually reaching the motor, and the power company thus benefits in proportion to the voltage reduction.

Power company engineers are familiar with these considerations and can be expected in many cases to approve the use of full-voltage starters for large motors on their lines when they are fully cognizant of the conditions, even though without such information they might normally specify that the motors be equipped with reduced-voltage starters.

[1] "Co-ordinating Electric Pipe-Line Pumping Equipment," by W. G. Taylor, *The Petroleum Engineer*, March, 1942, pp. 104-112.

'INCOR' COMES THROUGH IN THE PINCHES

FOR wells of moderate depth, here's a rule that never lets you down—*play safe . . . use 'Incor'.* Over 15 years' performance in thousands of wells proves the point. Just recently, a big operator was drilling to protect a West Texas lease. The job seemed to have the Indian sign on it—twistoffs, mud trouble, stuck pipe . . . grief all the way. Finally, top of pay was reached.

To save time, five attempts were made to run a wall packer and acidize the pay. Each time, the packer fouled on the whipstock. With the lease expiring in 36 hours, they decided to take a chance and run 6200' of 5" pipe. *When it came to cement, they weren't taking chances...* from years of experience they knew what 'Incor' would do. An emergency call brought a Lone Star Cement field service man to the job—and he stayed with it.

The pipe was run into the hole in 7 hours . . . 250 sacks of 'Incor' were mixed in 13 minutes . . . drillable plug hit bottom 37 minutes after the first sack of cement was mixed. In 8 hours, the first cement was drilled . . . 4 hours later, all cement and pay were drilled. Bottomed at 6260', exactly 5 hours ahead of deadline, the well produced enough oil to hold the lease. *A $150,000 investment saved.*

Yes, it pays to select cement to fit the job: Use 'Incor' for wells of moderate depth . . . 'Starcor' or 'Texcor' for deep wells . . . Lone Star for all-around oil-field service. The inbuilt extra quality counts when you need it most.

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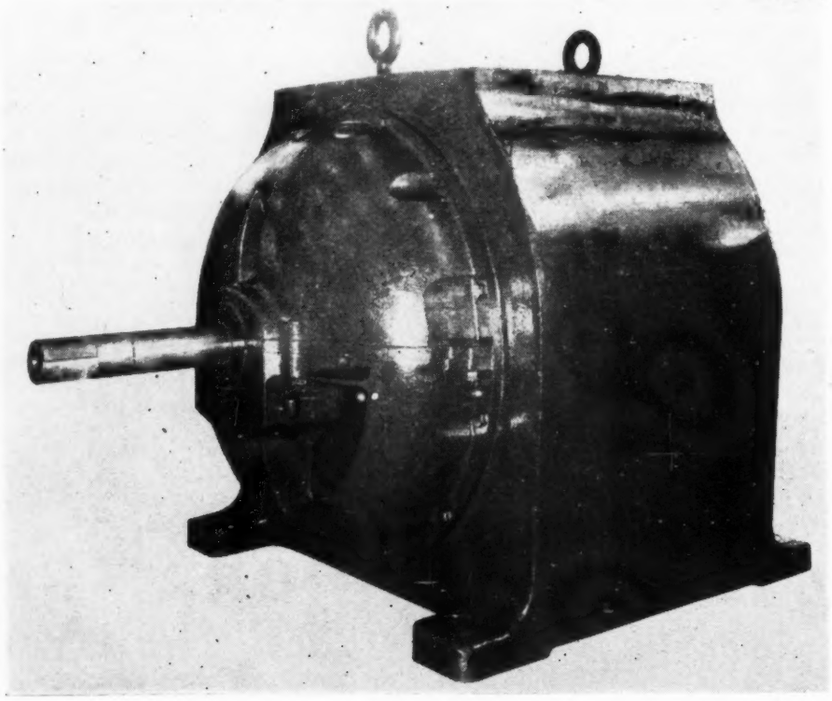
Full-Voltage Versus Reduced-Voltage Starting

Within reasonable limits, squirrel-cage induction motors may be designed with lower than normal starting current. This also lowers the inherent starting and maximum torque. The usual objective of such design is to lower the current peaks on the line and thus make full-voltage starting acceptable to the power company. It is inherently a substitute for the use of a reduced-voltage starter. If such a starter is proposed in combination with such a motor, an analysis is advisable of the extent to which the motor torque is likely to be still further reduced by voltage drop in power lines and transformers. It may indicate that only the full-voltage starting method will leave enough torque to get the motor and pump up to full speed in a reasonably short time or without sticking at about 75 percent of full speed. A long period of acceleration may trip out the temperature overload relays that protect the motor, and may even result in undesirable heating of the pump when operating with closed discharge. It is important, therefore, that all factors be studied.

Another factor involved is the cost of reduced-voltage starting equipment as compared with that for full-voltage starting. The former has approximately twice the cost of the latter in the high-interrupting capacity type for 2300 volts. With a heavy voltage drop through the transformer during the worst starting condition, and consequently only a narrow torque margin remaining for motor and pump acceleration, the indication is likely to be that a reduced-voltage starter does not have a sufficiently useful place in the picture to warrant the added expense. It should always be kept in mind that these conditions actually result in starting the motor at reduced voltage even though it is connected directly across the line.

If a reduced-voltage starter is applied under such conditions, it is always possible to make use of it. The timing of the relay, which automatically shifts the motor connection directly to the line after it has accelerated at reduced voltage, can be adjusted to make this change before the motor speed has reached the critical point where the torque margin is undesirably small. Although this will result in a higher current peak, this peak will still be about 10 or 15 percent less than a full-voltage starting peak. There is also the possibility of increasing the torque margin by throttling the discharge valves of the pumps that are already running, and thus reducing the voltage drop by decreasing the load amperes. It may also be possible to boost the available voltage by changing taps on the station transformer or even by raising the voltage on the power system, and thus increasing the available motor accelerating torque. Still another possibility of improving voltage conditions, when necessary, might be by the use of capacitors. This would depend upon the nature of the load and the power situation, and would require a study of all factors to determine suitability and make a selection of type and size if conclusive advantages are evident.



The largest motors so far built for pipe-line service. This is one of the 1500-hp., 1800-r.p.m., 2300-volt motors for the main pumps on the War Emergency Pipeline

Interrupting Capacity

In the preceding article to which reference has already been made, stress was laid on the importance of providing sufficient interrupting capacity in the control equipment used. It should be foremost in the mind of the pumping station designer thus to avoid failures that might not only seriously interrupt pumping service and result in expensive repairs, but also endanger the safety to the station operator. In stations equipped with large motors, as is the case, for example, on the War Emergency Pipeline, oil circuit breakers are at present required to provide high interrupting capacities, but when motors of smaller sizes are involved, they may be within the present available capacity of the comparatively new current-limiting fuses. Motor starters incorporating these fuses have been developed and are being widely applied on 2300-volt circuits to provide interrupting capacity up to 150,000 kva., which is well in excess of the requirements of any pipe-line pumping station so far contemplated. An advantage of this type of control, which may be obtained for either the full-voltage or the reduced-voltage starting method, is its comparatively low cost. The fuses are especially suitable for indoor installation because if they are blown they are silent in operation and emit no gas, flame, vapor, or metal. As they are selected to operate only under actual short-circuit conditions, unnecessary blowing will not occur. Many of the auxiliary motors in the War Emergency Pipeline stations are equipped with this type of control, at a very substantial saving in investment.

Conclusion

It should now be obvious that behind the spectacular phases of pipe-line construction are many problems that are vital to the success of such a project and require much time and thought to solve. It is hoped that this discussion of some of the principal electrical problems will make it evident that they are among the first that should be studied and settled, so that the completion of the project in the time planned may be more readily assured by the prompt placing of orders for equipment.

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P 420.111.

Inspection and Analysis Of Formation Samples

PETROLEUM ENGINEER Exclusive Feature

☆ Determination of porosity and grain-size distribution

by Lester C. Uren

Professor of Petroleum Engineering, University of California

PREVIOUS articles of this series have been concerned with methods of procuring samples of the formations penetrated in the routine of well drilling; of giving them preliminary care and inspection at the wellhead and preparing them for shipment to the laboratory; of analytically determining their oil and water saturation and permeability. The present article will be devoted to a review of methods of determining percentage porosity and grain-size distribution of formation samples.

Percentage Porosity of Samples

The porosity of a rock specimen is defined as the ratio of the aggregate volume of its void pore spaces to its gross bulk volume. It is usually expressed as "percentage porosity," thus:

$$\text{Percent porosity} = \frac{\text{pore volume}}{\text{bulk volume}} \times 100$$

For some purposes, it is found convenient to distinguish between "total porosity" and "effective porosity." The latter is a measure of the ratio of the volume of the *communicating* pore space of a rock specimen to its gross bulk volume. It, too, is expressed in percentage. The term "communicating pore space" excludes pore spaces frequently present in rocks that are completely isolated from surrounding pore spaces, usually by processes of secondary cementation. It is not a term of absolute value, for the ability of a fluid to pass from pore to pore of a containing rock will be largely a matter of the pressure applied. Partially sealed pores may permit passage of fluids at very high pressure, but not at low pressure.

As indicated by the equation given above, to evaluate the percentage porosity of a rock specimen means must be found for quantitatively determining (a) the bulk volume of the specimen, and (b) the volume of the pore spaces. There are several different ways of determining each of these factors, and most of the methods produce closely comparable results. A device used for this purpose is called a "porosimeter."

LESTER C. UREN

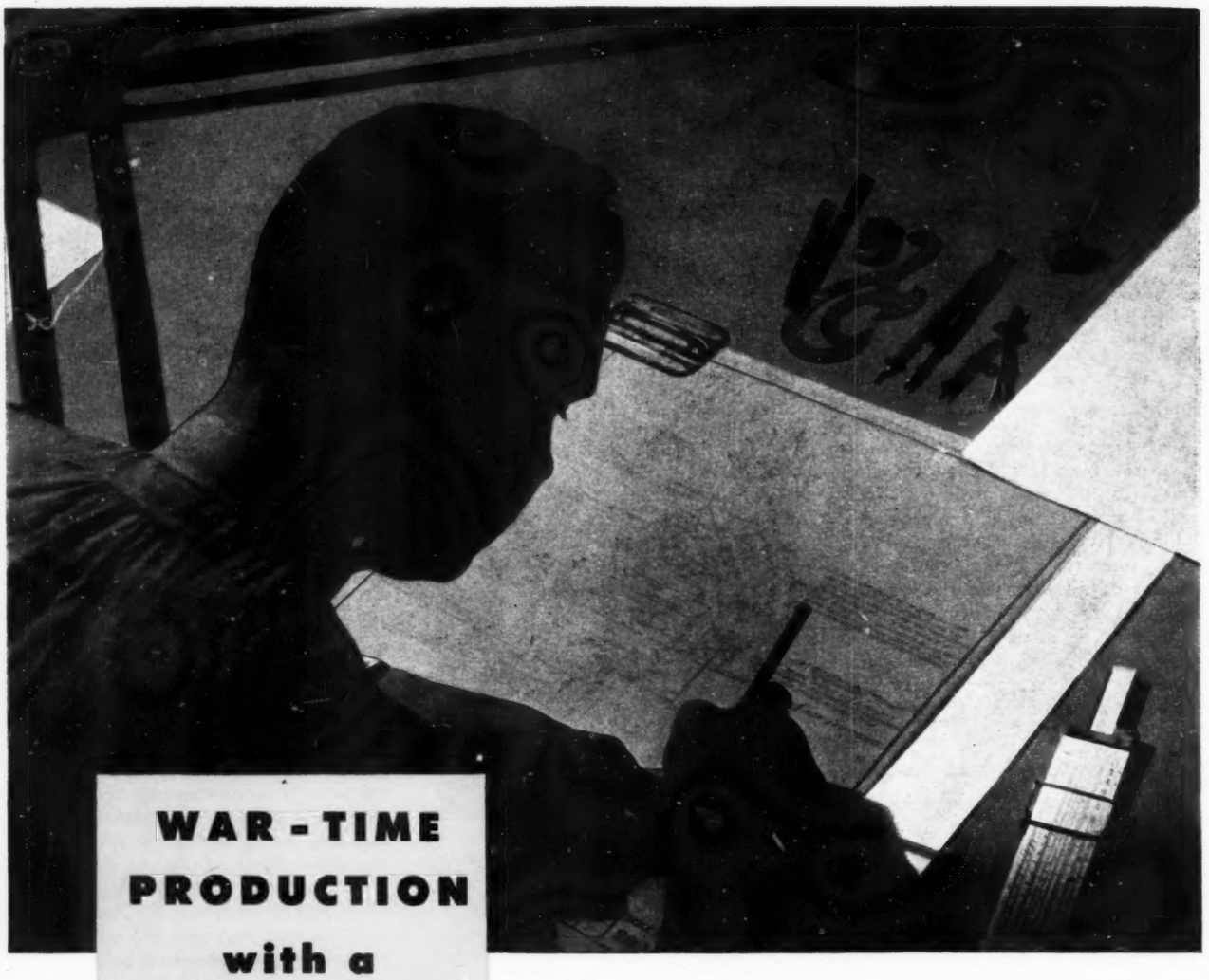
Measuring Bulk-Volume

Measurement of bulk-volume of a rock specimen may be done (1) by immersion in a liquid, such as mercury, which does not enter the pore spaces of the specimen, and measuring the increase in volume of the liquid; (2) by saturating the pore space with a liquid, such as acetylene tetrachloride, then immersing the specimen in a measured volume of a fluid and noting the increase in apparent volume of the fluid; (3) by coating the specimen with a water-impervious substance that does not enter the pore spaces of the specimen, then weighing the coated specimen, first in air and then in water, and computing the volume from the known density of the water and the loss of weight when immersed in water; (4) If the specimen is dressed to some regular geometrical form, such as a cube, its bulk-volume can be computed directly from its measured dimensions, and (5) If the volume of the pores and specific gravity of the mineral substance of which the specimen is composed are known, the bulk volume can be computed from the dry weight of the specimen.

1. Determination of bulk volume by mercury displacement. This is one of the most commonly used methods of determining bulk volume, especially when the sample is sufficiently well cemented so that it does not disintegrate readily. Due to its very high surface tension, mercury does not readily "wet" nor enter the pore spaces of a rock specimen immersed in it. Taking advantage of this peculiar property of mercury, we may determine the bulk volume of a rock specimen in either of three ways: (a) By determining the dry weight of the sample in air, then determining the weight necessary to immerse it in mercury. The bulk volume may be calculated by dividing the sum of the two weights by the specific gravity of mercury. (b) By filling a pycnometer of accurately determined volumetric content, with mercury, then inserting the test specimen and measuring the volume of the mercury displaced. (c) By partially filling a graduated burette with mercury, immersing the rock specimen in it and noting the increase in apparent volume of the mercury.

A convenient device utilizing the latter method is described by Pyle and Sherborne. This consists of a graduated glass volumeter with a closed bulb at one end and an enlargement at the other open end that is fitted with a ground glass stopper. (See Fig. 1.) The tube is partially filled with mercury, the stopper inserted and held securely in position while the tube is turned upside down. With the volumeter in this position, the volume of mercury in it is observed by reference to the graduations. The volumeter is again turned so that the stopper end is uppermost, the stopper removed and the rock specimen inserted in the open enlarged end. The stopper is again pressed securely into position, the apparatus again inverted and the apparent volume of mercury again observed. The apparent increase in volume of the mercury is the volume of the rock specimen.

2. Determination of bulk volume by fluid displacement of a saturated rock specimen. Utilizing this principle, we may differentiate between (a) methods that make use of a liquid as the displacement medium, and (b)



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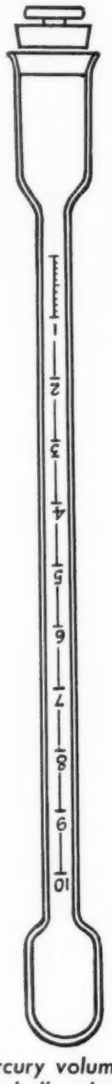


Fig. 1. Mercury volumeter used in determining bulk volume of formation samples
(After Pyle and Sherborne in A.I.M.E. Petroleum Development and Technology)

methods that make use of a gas as the displacement medium.

W. L. Russell has described an apparatus and a method that is widely used in determining bulk volume, which makes use of a special form of volumeter or pycnometer and employs acetylene tetrachloride as the displacement and pore-saturation medium. This fluid readily enters and completely fills the pores of a rock specimen. Kerosine or tetrachlorethane or any other liquid of low viscosity that "wets" the sample freely, may be used instead of acetylene tetrachloride. The special form of pycnometer used, illustrated in Fig. 2, consists of two graduated tubes, which are enlarged at one end to form reservoir "A," while at the other end they are connected by reservoir "B." The glass tube forming the latter is ground on its exterior surface and is provided with ground-glass stopper, "S." The apparatus is so constructed that when the stopper is in place, as shown in the sketch, the volume below the point "M" on the graduated tubes is equivalent to that above the uppermost graduation, "N." In making a bulk-volume test with this apparatus, the rock specimen is first immersed in acetylene tetrachloride in a separate container from which air is exhausted by a vacuum pump, until air bubbles cease to issue from it. The saturated specimen is then removed, the liquid adhering to its outer surface is wiped off, and it is then placed in reservoir "B," this end of the pycnometer being held uppermost with stopper "S" removed, and the apparatus filled to mark "N" with acetylene tetrachloride. Stopper "S" is then placed in position with the ground surfaces greased to prevent leakage, and the pycnometer is inverted to the position shown in the sketch. The apparent increase in volume of the fluid in the pycnometer may then be determined directly by reference to the graduations on the tubes between "M" and "N." This is taken as the bulk volume of the specimen.

Porosimeters designed primarily to determine the volume of the mineral content of a specimen rather than the bulk volume, can be used for the latter purpose by dipping the specimen in molten paraffin, thus sealing the interior pore space against contact with exterior fluids. For example, the hydrogen porosimeter described below may be used in this way. In this device a gas such as hydrogen is charged under pressure of several atmospheres into a steel bomb containing the paraffin-coated specimen. The gas so imprisoned is then allowed to expand into a second container to a lower pressure. Known volumes of the intercommunicating containers, and the indicated gauge pressures before and after expansion, provide a basis for computation of the volume of the specimen. A bulk-volume test of this character can best be made after a test in the same apparatus and with the same specimen to determine the volume of the mineral substance of the specimen, as explained in a later section. Correction for the volume of the paraffin, determined as described in the next section, is subtracted from the apparent volume of the specimen.

3. Determination of bulk-volume of a rock specimen by coating with paraffin and weighing in air and water. A method developed by A. F. Melcher, involves first coating the specimen with molten paraffin, then weighing the coated specimen in air and later in water by suspending it from the beam of a balance with a fine silk thread or wire. Weighing both before and after coating, provides a means of determining the weight of the paraffin adhering to the specimen, and from its known density (0.906), the volume of the paraffin may be computed. The loss of weight of the specimen while immersed in water, in comparison with its weight in air, is a measure of the weight and volume of the water displaced. The volume of water displaced, less the volume of the paraffin coating, is the bulk-volume of the specimen.

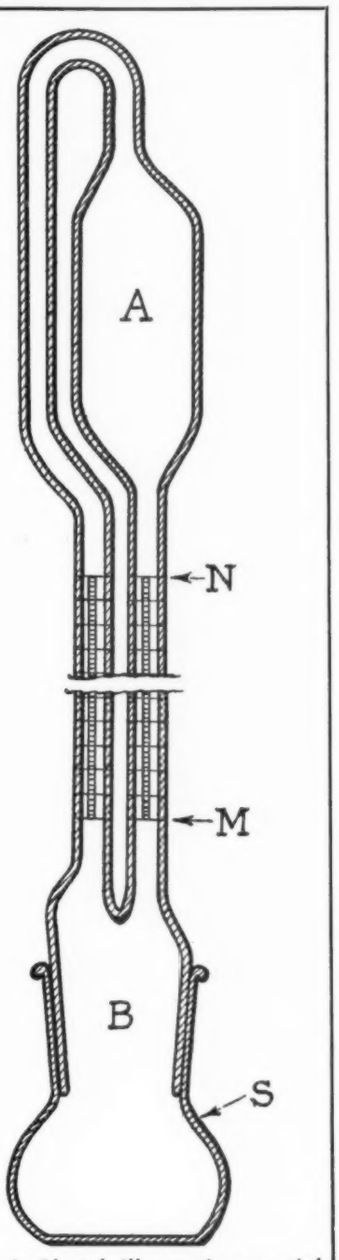


Fig. 2. Sketch illustrating special form of pycnometer used in determination of porosity of sandstone by saturation with and immersion in a liquid such as acetylene tetrachloride
(After W. L. Russell in A.A.P.G. Bulletin)

4. Direct computation of bulk volume by dimensional measurements of specimens dressed to geometric forms. If the specimen is a firm, well-cemented sandstone, and has been cut in true cylindrical or cubic form, the bulk volume can be determined by taking accurate measurements of functional dimensions and computing directly the bulk volume.

5. Determination of bulk-volume from weight, specific gravity, and pore volume of a rock specimen. If a specimen is of some pure mineral substance, the specific gravity of which is known (i.e., quartz, which has a specific gravity of 2.65), to determine the volume of the mineral substance, we have but to determine the dry weight of the sample and divide it by the specific gravity. Then, if the volume of the pore space can be determined by one or another of the methods described below, the bulk-volume is equal to the sum of the pore volume and the mineral volume.

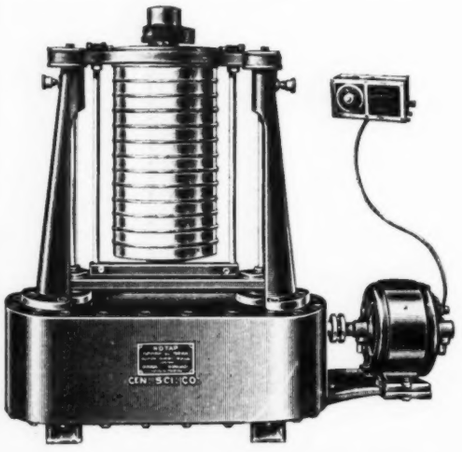
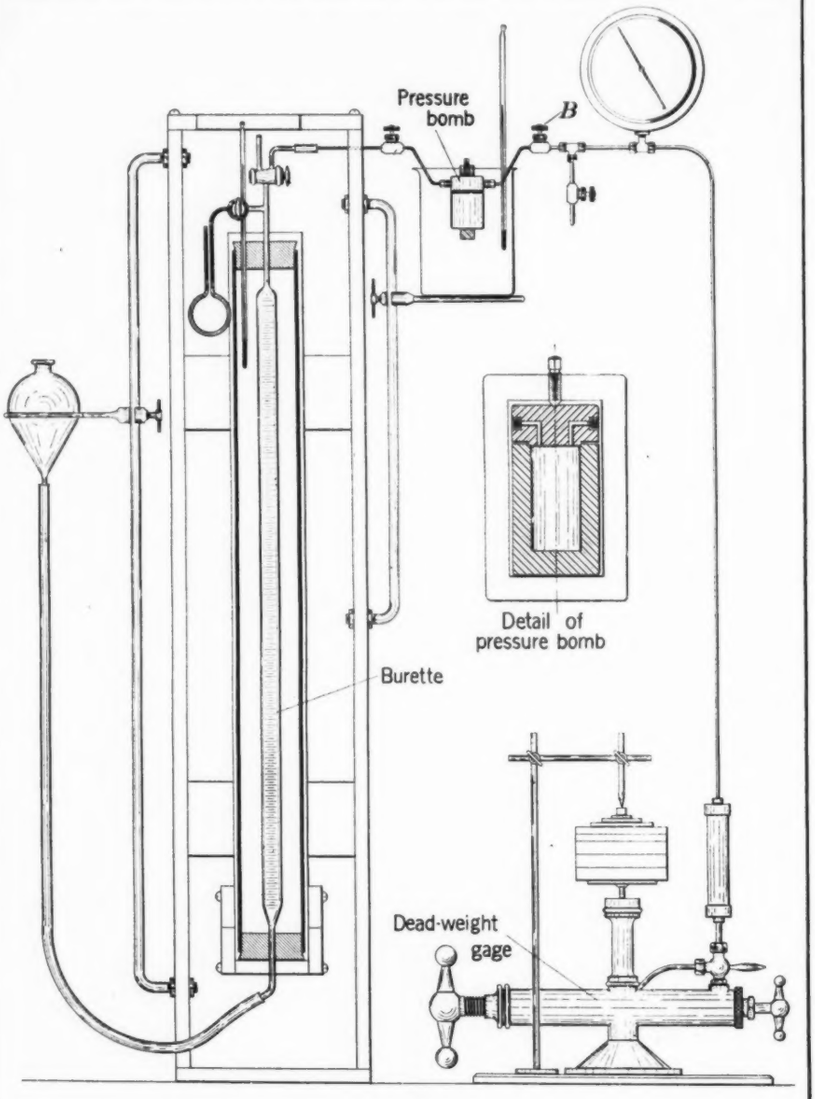


Fig. 4. "Ro-Tap" testing sieve shaker
(Courtesy Central Scientific Co.)

Fig. 5. Dulin "Rotarex"
(Courtesy Fisher Scientific Co.)

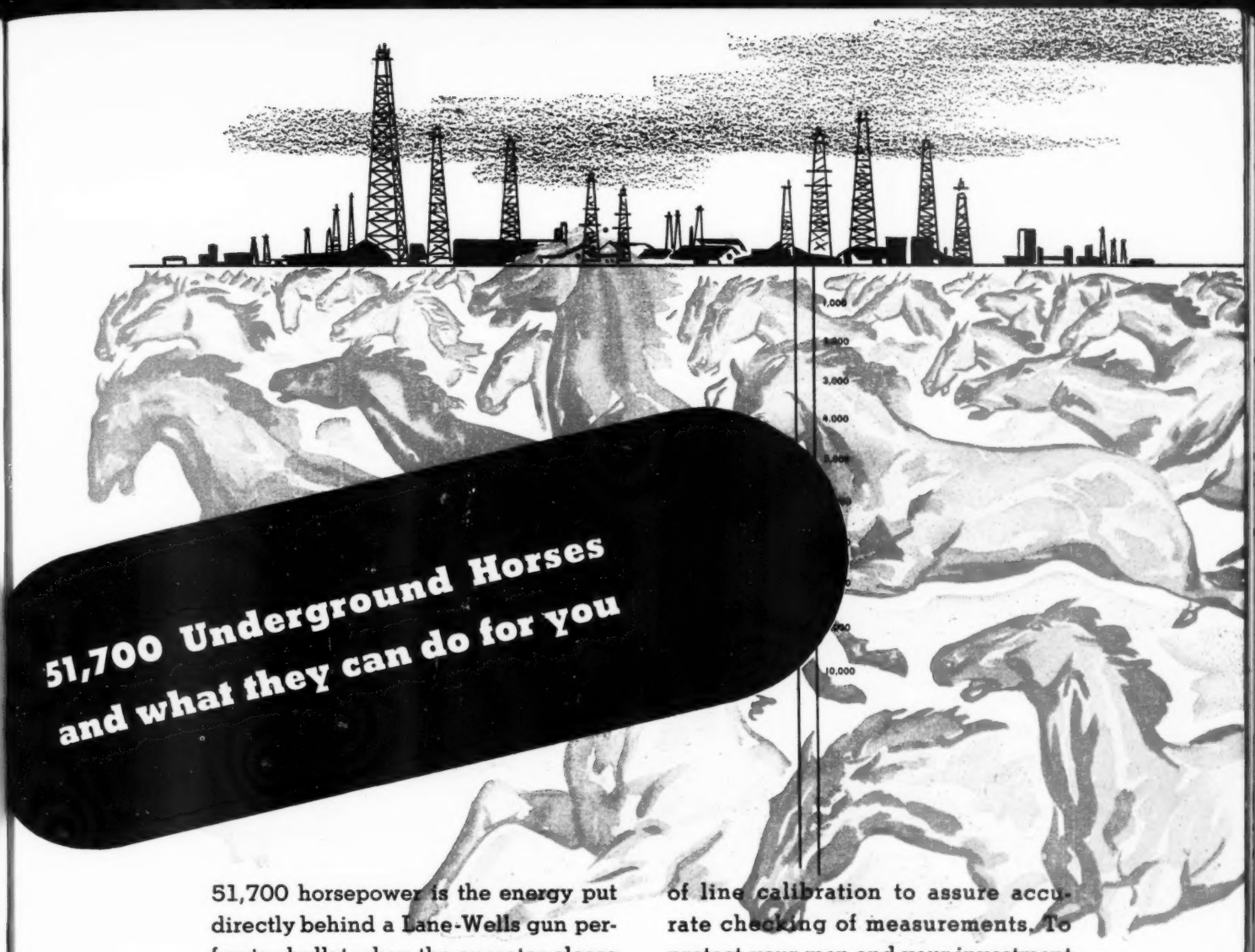
Fig. 3. U. S. Bureau of Mines "Boyle's Law" Porosimeter
(After D. B. Taliaferro, Jr., T. W. Johnson, and E. J. Dewees in U. S. Bureau of Mines R.I. 3352)



Measuring Volume of Pore Space

The volume of the pore space within a rock specimen can be determined indirectly by measuring the bulk volume and mineral substance volume. Subtracting the volume of the mineral substance from the bulk volume, gives the volume of the pores. We may determine the volume of the mineral substance in either of several ways: (1) By gas displacement; (2) by comparison of the dry weight of the specimen with the weight when saturated with and immersed in a liquid of known density; (3) by comparison of the dry weight of the specimen with its weight when saturated with a liquid of known density, and (4) by crushing the sample to separate the individual gains and then determining their volume by weighing them in a pycnometer of known volume.

1. Determination of the volume of the mineral substance of a rock specimen by gas displacement. The so-called "Bureau of Mines" or "Boyles Law" porosimeter, commercially available, consists of a steel bomb with facilities for filling it with gas under closely controlled pressure, and then measuring the volume of gas by expansion into a graduated burette. (See Fig. 3.) A gas, such as air or hydrogen, is charged into the empty bomb to a pressure of four or five atmospheres, and then expanded by releasing it slowly to the graduated burette where its volume is accurately measured. A duplicate test is then made with the mineral specimen in the bomb. As the pore space of the specimen is penetrated by the gas, the difference between the volumes of gas so determined is a measure



51,700 horsepower is the energy put directly behind a Lane-Wells gun perforator bullet when the operator closes the firing switch.

This tremendous impact drives the bullet through as many as three cemented strings of casing and sends it far out into formation to open channels through which oil can flow.

To control the power of the gun and place each hole exactly where you want it, Lane-Wells developed a system of line calibration to assure accurate checking of measurements. To protect your men and your investment in your well Lane-Wells installed a five-point safety system to guard against pre-mature firing.

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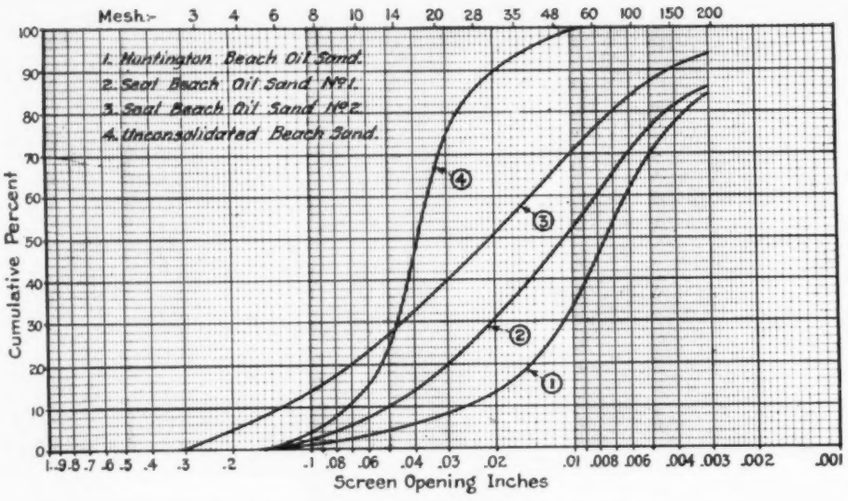

Mesh:- 3 4 6 8 10 14 20 28 35 48 60 100 150 200
1. Huntington Beach Oil Sand.
2. Seal Beach Oil Sand No 1.
3. Seal Beach Oil Sand No 2.
4. Unconsolidated Beach Sand.
Cumulative Percent
Screen Opening Inches
1. .9 .8 .7 .6 .5 .4 .3 .2 .1 .08 .06 .04 .03 .02 .01 .008 .006 .004 .003 .002 .001

Fig. 6. Illustrating method of plotting results of screen analyses on semi-log coordinate paper
(From the author's "Oil-Field Development," McGraw-Hill Book Co., Inc.)

of the volume of the mineral grains of which the specimen is composed.

2. Determination of the volume of the mineral substance of a rock specimen by comparison of its dry weight when saturated with and immersed in a liquid of known density. The volume of the mineral substance in a rock specimen may be computed by subtracting from the dry weight of the specimen in air, its weight when suspended on a slender thread or wire from the beam of a balance in a liquid that freely enters its pore spaces. The difference between these two weights is a measure of the weight of the fluid that the mineral substance displaces. From this, if the density of the fluid is known, we may compute the mineral volume. Kerosine or acetylene tetrachloride may be the liquid used, and to avoid imprisoned air bubbles in the specimen it may be saturated with the liquid in a closed vessel from which the air has been partially evacuated by a vacuum pump.

3. Determination of the volume of the mineral substance of a rock specimen by comparison of its dry weight with its weight when its pore spaces are saturated with a liquid of known density. We may compute the volume of the pore space in a rock specimen by first weighing it while dry in air, then saturating the pore spaces of the specimen with a liquid of known density. Subtracting the dry weight from the saturated weight, we obtain a figure that represents the weight of the fluid filling the pore spaces, and if we know the specific gravity of the fluid, we may compute its volume. A liquid of low viscosity that freely wets the mineral surfaces and penetrates the pore spaces—such as kerosine or acetylene tetrachloride—should be used, and precautions taken to avoid imprisonment of air bubbles in the pore spaces by conducting the saturation in a closed vessel from which the air has been partially evacuated. If we wish to know the volume of the mineral substance, we may subtract the volume of the pores thus determined from the bulk volume, but in computing percentage porosity this will be unnecessary if we can determine the volume of the pores directly.

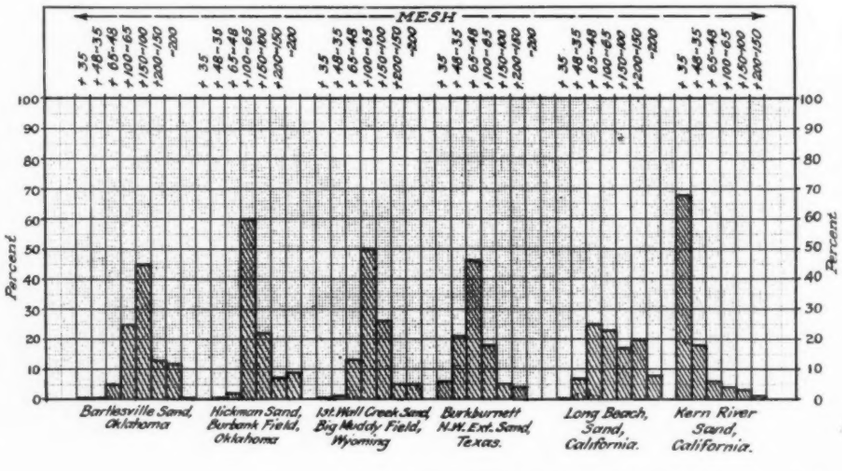
4. Determination of volume of the mineral substance in a rock specimen by crushing to separate its individual grains and weighing them in a pycnometer of known volume filled with liquid of known density. After determining the bulk volume of a specimen by one or another of the methods described above, it is crushed in a mortar to release its individual grains from each other. The mineral fragments are then thoroughly washed in a volatile oil solvent, dried, and weighed in a pycnometer of known volume. A liquid of known density, such as kerosine, is then poured into the pycnometer containing the sample until it is full, the perforated stopper is inserted, the outside of the pycnometer wiped free of excess fluid, and the weight again determined. The difference between the two weights will be the weight of the fluid added to fill the pycnometer, from which the volume of the fluid may be determined if its density is known. This volume is then subtracted from the volume of the pycnometer, to determine the volume of the mineral grains.

5. Determination of volume of the mineral substance in a rock specimen by dividing the weight of the specimen by its average specific gravity. An approximate calculation of the volume of the mineral substance in a rock specimen may be made simply by determining its dry weight and dividing by the average specific gravity of the mineral. The latter figure, of course, will ordinarily not be known with certainty, but it may often be assumed to be approximately that of quartz, (2.65). Most sands and sandstones are composed largely of quartz, and most common rock-forming minerals have specific gravities that do not differ greatly from that of quartz.

Determining Porosity

The "total porosity" of a rock specimen may ordinarily be determined only by crushing it to separate its component grains, then determining the volume of the grains and subtracting this volume from the bulk volume of the specimen. The "effective porosity" or the volume of the communicating pores, may be determined by any of the methods of measuring the volume of the pore space without crushing the specimen.

Fig. 7. Illustrating block method of displaying results of screen analyses of formation samples
(From the author's "Oil-Field Development.")



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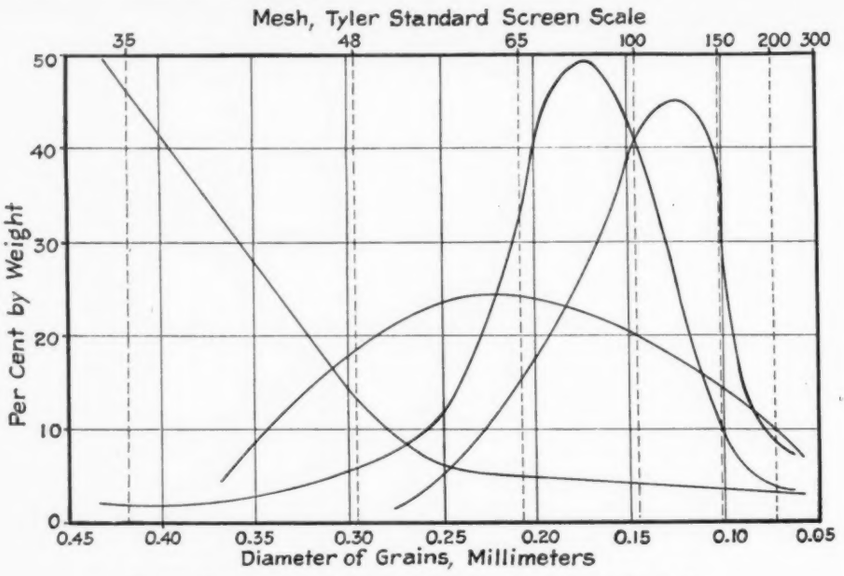

Fig. 8. Frequency distribution curves for typical oil sands

Determining Size Distribution

A complete laboratory inspection of a formation sample ordinarily involves application of tests to determine the size distribution of its component grains. This involves disaggregation of the sample in such a way as to release the grains from each other without crushing them to smaller fragments, and then subjecting a weighed sample of the disaggregated material to a process of screening or water classification. The percentages by weight of granular rock fragments segregated within different size ranges afford a basis for appraisal of grain-size distribution.

Disaggregation of granular rock specimens. The procedure to be followed in disaggregating a rock specimen will depend upon the extent of induration and character of the cementing material. Some sand specimens will crumble under pressure of the fingers; others can scarcely be broken under blows from a hammer. Often a laboratory mortar and pestle may be used advantageously, but methods involving impact or grinding forces are apt to abrade the mineral grains, reducing them to smaller size and destroying their native texture and crystalline form. Alternate heating and plunging in cold water will cause some rocks to disintegrate. Other methods of disaggregating specimens involve use of fluids that enter the pore spaces and expand as they solidify or freeze, and methods involving use of solvents to dissolve the cementing materials that bind the grains together.

Repeatedly saturating the pore spaces with water and freezing the saturated specimen in a refrigerator, then thawing, will disaggregate most granular rocks. Substances that melt in their own water of crystallization, such as sodium acetate or sodium thiosulphate ("hypo"), may also be used. Dry fragments of the specimen are placed in a suitable container with an equal amount of the crystallized reagent, a few drops of water are added, and heat applied until the crystals melt and enter the rock pores. On cooling, a few crystals of the reagent are added, recrystallization occurs, and the resultant expansion disintegrates the rock specimen. It may be necessary to repeat the process several times before disaggregation is complete.

If the cementing material binding the mineral grains together is carbonate of lime, and the grains are siliceous in character, washing with dilute hydrochloric acid will dissolve the cementing material and release the grains. A dilute acid wash is also helpful in removing from the mineral grain surfaces incrustations of other secondary material, thus facilitating lithologic inspection and identification of mineral character under the microscope.

Leaching with solvents to remove residual oil. Prior to screening, residual oil that may be present in disaggregated samples must be thoroughly removed, otherwise the mineral grains will tend to adhere to the screens or to each other. This may be done by repeated washing or leaching with a suitable solvent, such as carbon tetrachloride or ether. A Soxhlet extraction apparatus, previously described, may be used for this purpose, or a small bowl-type centrifuge, such as the Dulin "Rotarex." (See Fig. 5.) After washing or leaching the sample must be thoroughly dried, preferably by heating for a time at a temperature of less than 210° in an electric oven.

Screen-sizing of disaggregated formation samples. The usual method of determining grain-size distribution is to classify a weighed amount of the component grains of the disaggregated sample by screening through a series of nested screens of appropriate sizes. The percentage of the total sample, by weight, retained on each screen provides an index of the grain-size distribution. Screens employed for this purpose are constructed of brass-wire mesh, or in the finer sizes, of silk fabric, mounted in shallow cylindrical pans, 6 to 12 in. in diameter. Tyler standard screens are commonly used, ranging from 10 to 200-mesh. For very fine material, a 325-mesh screen is also available. The Tyler screen scale is so designed that the width of each successive screen opening in the series is 1.414 (i.e. $\sqrt{2}$) times the width of the opening in the next smaller size. Table I gives the sizes of screen openings in the Tyler standard screen scale.

In conducting a screening test, the screens are nested in the order of size, with the coarsest screen on top. An accurately weighed portion of the disaggregated, washed, and dried sample is placed in the upper pan, the screen cover is placed in position on top and a receiving pan on the bottom of the pile of nested screens, and the assembly shaken with an undulating, circular motion. In order that comparative results may be obtained, a standard procedure should be developed governing the time, manner, and vigor with which the screens are shaken. Hand methods are laborious and likely to be erratic in these respects, so it is considered better to employ mechanical shaking devices that have been developed for this purpose. For example, the "Ro-Tap" testing-sieve shaker illustrated in Fig. 4, assures that each sample will be subjected to precisely the same treatment. This machine reproduces the circular motion given testing sieves in hand screening, and provides in addition a vertical vibrating force that prevents the screens from clogging. Because of the uniform mechanical action, comparable results are thus attained in successive tests. With such an appliance,

TABLE I

Sizes of commonly used screens in the Tyler standard screen scale

Mesh	Size of screen openings Inches	Millimeters
10	0.065	1.651
14	0.046	1.168
20	0.0328	0.833
28	0.0232	0.589
35	0.0164	0.417
48	0.0116	0.295
65	0.0082	0.208
100	0.0058	0.147
150	0.0041	0.104
200	0.0029	0.074
325	0.0017	0.044

Baash-Ross News

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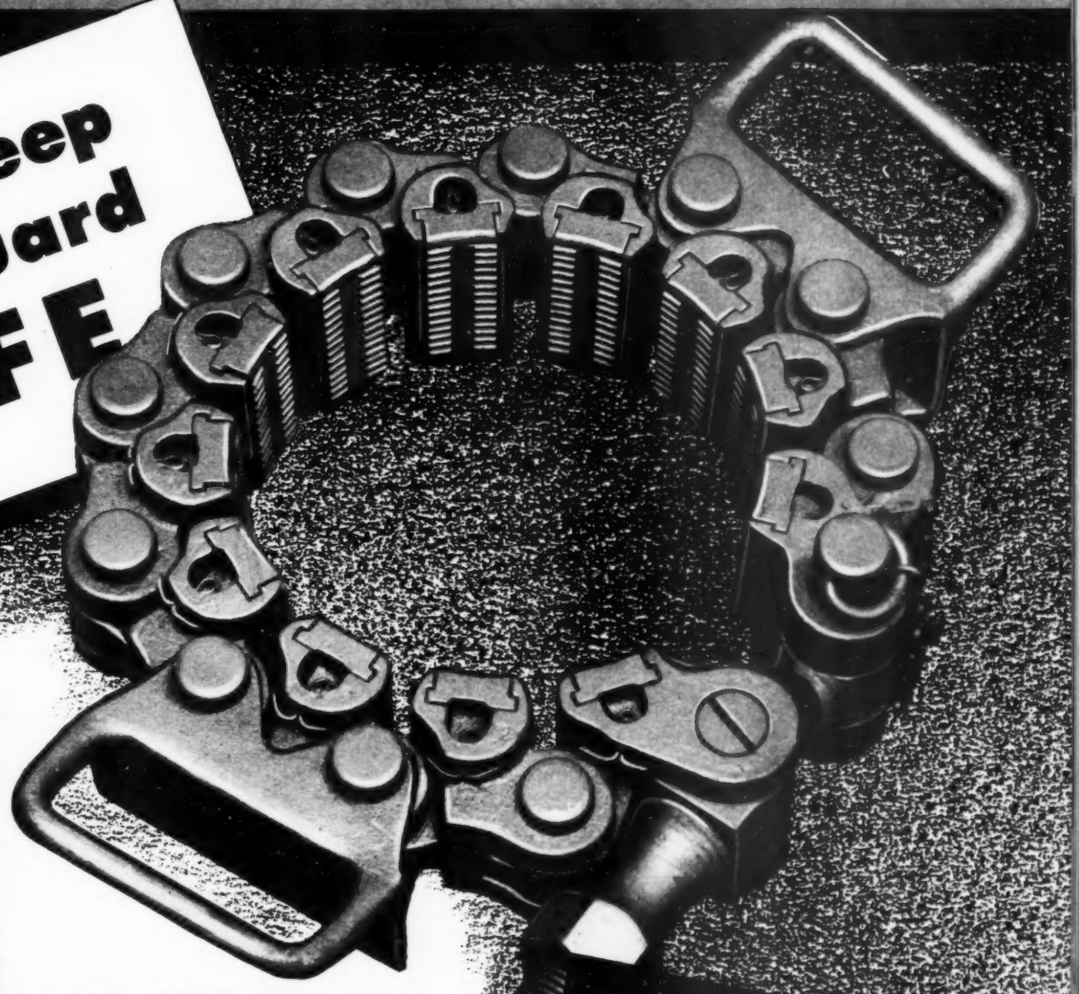
PETROLEUM ENGINEER EDITION

How to keep a safeguard SAFE



MANY OPERATORS tell us that one of the best all-around investments they ever made in rig equipment is the Baash-Ross Safety Clamp. Not only is it an ideal safeguard against dropping drill collars and other flush joint equipment down the hole, but it also is proving a valuable aid to production work and it simplifies many fishing operations. Baash-Ross Safety Clamps will be difficult to obtain for the duration. So here's how to insure long life and topmost efficiency from the Safety Clamp on *your* rig . . .

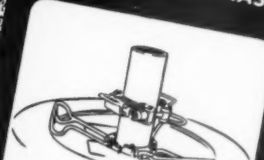
The important feature that enables the Safety Clamp to take a bull dog grip on even the smoothest case-hardened surface is the unique "sliding slip" built into each individual link. When the clamp is first tightened around the pipe these slips take a firm initial hold. Then any increase in the load causes the slips to slide up on their tapered seats and wedge tighter against the pipe, rigidly locking the clamp against movement. Because these slips must be free to slide *the instant* increased pressure is applied, the sliding surfaces must be kept clean and friction-free at all times. So don't allow rotary mud to cake on the clamp . . . nor heavy greases or dirt to collect!

Should the sliding surfaces of the gripping members become dry, they cannot operate efficiently. . . More important—dry surfaces are apt to gall under sudden impact loads, damaging the Clamp so that repairs or replacements might be necessary. Therefore, keep the clamp well lubricated with a very light penetrating oil that won't gum or thicken!

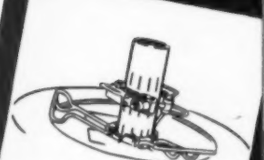
AN EASY WAY to keep your Safety Clamp BOTH clean and properly lubricated is to fill the metal case in which you store the Clamp with a good grade of kerosene or cleaning oil. The case has been particularly designed with welded corners and a solid bottom that will not leak. Keep the Clamp immersed in the fluid when it is not in use . . . and after use be sure to flush all mud and dirt off the Clamp before returning it to the case. This will keep the fluid clean and free of grit.

That's about all the maintenance your Safety Clamp requires . . . but it is vitally important maintenance! Just be sure you fill the case with fluid that is light enough to have a cleaning action—yet has sufficient lubricating value to keep the surfaces oiled. Either kerosene or light flushing oil will prove satisfactory!

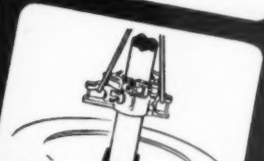
ARE YOU GETTING FULL SERVICE FROM YOUR BAASH-ROSS SAFETY CLAMP



YOU probably are already using your Safety Clamp to safeguard against dropping drill collars in the hole while making them up or breaking them out of the string . . .



BUT have you tried using it to safeguard against dropping other types of flush surfaced equipment such as flush joint drill strings, liners and screens?



OR as an emergency elevator shoulder when recovering twist-offs and similar fish? One operator safely supported a 4000' drill string this way while lifting it far enough to get a collar in the clear!

OR for holding gravel-packed liners in the table while making them up? These liners usually have insufficient room between collar and jack for elevators. So put the Clamp in this space and support the liner through a "U" plate on the table. Gives ample room for tongs!

the whole process of screening can be standardized to a degree not possible in hand screening.

After screening, the component fractions of the sample will be found segregated on the various screens in accordance with their respective sizes. After the nested screens have been separated, the material retained on each is carefully collected and weighed and its percentage of the gross weight of the original sample is computed. Results may then be conveniently tabulated with a view toward convenient use.

Determination of size-distribution of granular mineral particles by water classification. Alternative methods of size classification include elutriation and determination of the rate of settling in water. An elutriator provides a vertical tube through which a liquid, such as water, flows upward with controlled velocity. If the disaggregated sample is of uniform density, particles above a certain size will sink in the ascending stream of fluid, whereas smaller particles will be swept upward, caught in a settling chamber, collected, dried, and weighed. By varying the rate of ascending velocity of the fluid in successive tests, "crops" of different sizes may be segregated. Calibration of the instrument may determine the rate of flow of the fluid to segregate a component of a given maximum size. Repeated elutriation of the heavy "crops" will provide data for a complete size-distribution analysis.

Differences in the rate of settling of mineral particles of varying sizes in a stationary column of water or other liquid may provide data for a grain-size analysis of a disaggregated formation sample. Stokes' law, which is found to govern in such a system, providing we do not enter the realm of "hindered settling," states that:

$$r^2 = \frac{9}{2} \frac{u\,h}{(M\text{-}L)\,g\,t}$$

Where:

- r = the radius of the settling particle, cm.,
- u = the absolute viscosity of the liquid in poises,
- h = the distance settled, cm.,
- t = the time in seconds for the particle to sink h centimeters,
- M = the density of the mineral;
- L = the density of the liquid, and
- g = the acceleration of gravity (980 cm., per sec. per sec.).

Stokes' law holds only for particles of spherical form, which of course, seldom exist in nature. The shape of the mineral particles will influence its rate of settling, flaky, platy particles settling less rapidly than rounded forms. Tickell* proposes the following formula, which includes a shape factor adapting it to average mineral grain forms:

$$d = \sqrt{\frac{v}{700}}$$

This formula applies only to quartz particles (density 2.65) of diameter "d", settling in water. Water classification methods are tedious and difficult, and are recommended for use only in size analysis of mineral particles too small for effective screening, i.e. less than 200-mesh.

Graphic methods of displaying the results of size-distribution analyses. Results of screening tests can conveniently be displayed in graphic form. A common type of screen analysis graph is one in which cumulative percentages are plotted against the size of screen openings, thus showing the percentages larger and smaller than each size of screen. Such graphs may be plotted on natural or arithmetic coördinates, but a more convenient form of graph utilizes "semi-log" coördinate paper, using the natural scale for cumulative percent of weights and component fractions, and the logarithmic scale for sizes of screen openings. (See Fig. 6.) A simple and easily understood method of presenting the results of screen analyses, called a "histogram," is illustrated in Fig. 7.

Still another method of interpreting the results of a screen-sizing test in graphic form, is the "frequency distribution" curve. This type of curve displays in graphic form, the relative frequency with which particles in different sizes occur in the formation sample, reaching a peak at the point on the scale where the most abundant size of particle is found. (See Fig. 8.) The manner in which the different sizes are grouped on either side of this high point on the frequency curve is a significant characteristic of the sample for some purposes. Lack of symmetry of the curve about this peak is called "skewness," and a concentration of frequencies over a narrow range is called "kurtosis." These terms may be expressed quantitatively, with reference to the size-distribution curve, according to arbitrary conventions.* Thus:

$$\text{Skewness} = P_{50} - \tfrac{1}{2}\,(P_{10} + P_{90});$$

$$\text{Kurtosis} = \frac{P_{25} - P_{75}}{2\,(P_{10} - P_{90})}$$

In these expressions, P signifies the percentile point on the curve indicated by the subscript. Thus, P_{10} is the percentage by weight of that grain size at which 10 percent of the grains are larger and 90 percent smaller. Skewness may be either positive or negative. A negative value indicates that more of the material is fine grained than coarse grained.

*"Statistical Method," T. L. Kelly, p. 77 (1924).

☆ ☆ ☆

*"The Examination of Fragmental Rocks," F. G. Tickell, Stanford University Press.

Fuel Consumption at Refineries

The average heat requirement per bbl. of crude refined in the United States increased from 579,000 B.t.u. in 1940 to 580,000 B.t.u. in 1941, according to a report by the U. S. Bureau of Mines. This marked the second successive year in which there was an apparent loss in fuel efficiency at refineries. This "loss" took place despite an increase in crude runs, which used to be an invariable indicator of a lower average.

Probably the chief factor in the increased heat requirement in 1941 was the gain in the overall gasoline yield from 43.1 percent in 1940 to 44.2 percent in 1941. Possibly another important factor was the further use of obsolete equipment to increase throughput.

The refiners used more of all kinds of fuel except coke in 1941 than in 1940. The only fuels that increased materially in relative importance were refinery gas, which contributed 51.6 percent of the total heat units in 1941 compared with 50.7 percent in 1940, and natural gas, the share of which increased from 17.1 percent in 1940 to 18.0 percent in 1941. The changes in the percentages for the other fuels were as follows: Oil decreased from 25.7 to 24.1 percent; acid sludge decreased from 2.7 to 2.5; coal remained at 3.4 percent, and coke (including steam) declined from 0.5 to 0.4 percent.

New records for fuel efficiency were set in all three of the districts east of the Mississippi, namely, East Coast, Appalachian, and Indiana, Illinois, etc. All the other districts reported higher average fuel requirements in 1941, except the Louisiana Gulf and Arkansas-Louisiana inland.

Since the year of the first statistics, the refiners have steadily increased their purchases of electricity. In 1941 total purchases were 1,862,996,000 kw-hr., or 11 percent more than in 1940.

Solution of Flow Equations For Natural Gas Lines

PETROLEUM ENGINEER Exclusive

☆ Deriving and simplifying formulas in solving for values of terms employed

by P. McDonald Biddison and Griffith H. McKay

War Production Board

IN MONOGRAPH 6 of the U. S. Bureau of Mines,[1] the equation for flow of gas in natural gas transmission lines is given, for 24-hour flow rate, as follows:

$$Q = 38.7744 \times \frac{T_o}{P_o} \times d^{2.5} \sqrt{\frac{P_1^2 - P_2^2}{GTL}} \times \frac{1}{\sqrt{f}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

As f is dependent upon the Reynold's Number and the Reynold's Number is in turn dependent upon viscosity, specific gravity, and the relationship of the rate of flow to pipe diameter, this equation, though readily solved by slide rule for pressure conditions when the quantity and diameter are known, is impossible of solution by slide rule for quantity when pressures and diameter are known. A solution for quantity, by calculation of f, from pressures, diameter and the other known factors, somewhat tedious, is possible as shown by Biddison[2] and by Miller.[3]

P. McDONALD BIDDISON

is now a consulting engineer in the Chicago offices of the War Production Board—Prior to becoming affiliated with WPB he had operated since 1927 as a consulting engineer, making his headquarters in Dallas, Texas—He graduated in 1904 from Kansas State College of Agriculture and Applied Science with the degree of bachelor of science in electrical engineering—Followed association with a number of gas and engineering companies until he entered consulting work—He is a licensed professional engineer in the states of Texas and Oklahoma.

Because of the inconvenience in the solution of equation (1) engineers in the natural gas industry generally use the equation of Thos. R. Weymouth. This equation is readily solved by slide rule for either quantity or pressures and numerous slide rules and gas flow computers in current use are based upon it. Monograph 6 gives Weymouth's equation as follows:

$$Q_w = 433.488 \times \frac{T_o}{P_o} \times d^{2\frac{2}{3}} \sqrt{\frac{P_1^2 - P_2^2}{GTL}} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Here the subscript W on the quantity denotes the quantity obtained by the use of the Weymouth equation. By dividing equation (1) by equation (2) we obtain:

$$\frac{Q}{Q_w} = \frac{1}{\sqrt{f}} \times \frac{1}{11.18 \times d^{\frac{1}{6}}} \quad (3)$$

From this, if the quantities be identical, and using the subscript W to denote the friction factor of Weymouth's equation:

$$\frac{1}{\sqrt{f_w}} = 11.18\, d^{\frac{1}{6}} \text{ or } f_w = \frac{0.008}{d^{\frac{1}{3}}} \quad (4)$$

Equation (4) shows that the Weymouth equation assumes that the friction factor is a function of diameter only, when it is in fact influenced by several other factors. The friction factor may be expressed in this form:

$$\frac{1}{\sqrt{f}} = a \text{ Log } R\sqrt{f} + b \quad . \quad . \quad . \quad (5)$$

Three variations of this equation are shown and others may be written to accord with experience or tests. The Nikuradse data on smooth pipe[7] may be expressed as:

$$\frac{1}{\sqrt{f}} = 4.0 \text{ Log } R\sqrt{f} - 0.4 \quad . \quad (6)$$

On commercial pipe the efficiency of flow compared to smooth pipe may vary through wide limits depending upon the relative roughness of the interior surface and the amount of fouling. These factors may be allowed for by the use of an efficiency factor applied to equation (6) or by substituting other constants in equation (5). Drew and Genereau[6] taking into consideration the data of several investigators on commercial pipe suggest the following:

$$\frac{1}{\sqrt{f}} = 3.2 \text{ Log } R\sqrt{f} + 1.2 \quad . \quad (7)$$

Based upon flow records on the Pampa-Wichita 20-in. line of Cities Service Gas Company, cited by Benjamin Miller,[3] tests on the 24-in. line of Panhandle Eastern Pipe Line Company and an analysis of the field tests reported in Monograph 6[1] Biddison suggested[2] in a paper before the Natural Gas Section of American Gas Association that:

$$\frac{1}{\sqrt{f}} = 3.6 \text{ Log } R\sqrt{f} - 0.10 \quad . \quad (8)$$

It is not the purpose here to fix the

GRIFFITH H. McKAY

is consulting engineer for the Office of War Utilities of the War Production Board, resigning a position on the general engineering staff of the Arkansas Natural Gas Corporation to become affiliated with that body—He received a bachelor's degree in civil engineering from Mississippi State College in 1930—After graduation he was employed by Arkansas Natural and placed in their Junior Engineer Training Course, receiving office and field training in the various phases of the company's operations—Later was on the general engineering staff.

value of the friction factor. One may choose between the equations here shown or draw a straight line of his own choice on semi-log paper as has been done for equations (6), (7), and (8), on Fig. 2. The present purpose is to show, (a) a ready means of solution for quantity of equation (1) using friction factors in the form of equation (5) and (b) to show a ready means of converting a result obtained from the use of the Weymouth equation, either quantity or pressure, into the result that would have been obtained by the use of friction factors in the form of equation (5) and in equation (1).

If, in equation (1) we assume the value of $\frac{1}{\sqrt{f}}$ to be 1.0, we will obtain an incorrect value of the quantity, which we will label Q_x. We may then re-write equation (1) as follows:

$$Q_x = 38.7744 \times \frac{T_o}{P_o} \times d^{2.5} \sqrt{\frac{P_1^2 - P_2^2}{GTL}} \quad . \quad . \quad . \quad . \quad . \quad (9)$$

This equation is readily solvable by slide rule or calculation for quantity. Following the form of equation (1) we may substitute from equation (4) in equation (1) to obtain:

$$Q_w = 38.7744 \times \frac{T_o}{P_o} \times d^{2.5} \sqrt{\frac{P_1^2 - P_2^2}{GTL}} \times 11.18 d^{1/6} \quad . \quad . \quad . \quad (10)$$

Dividing equation (9) by equation (10):

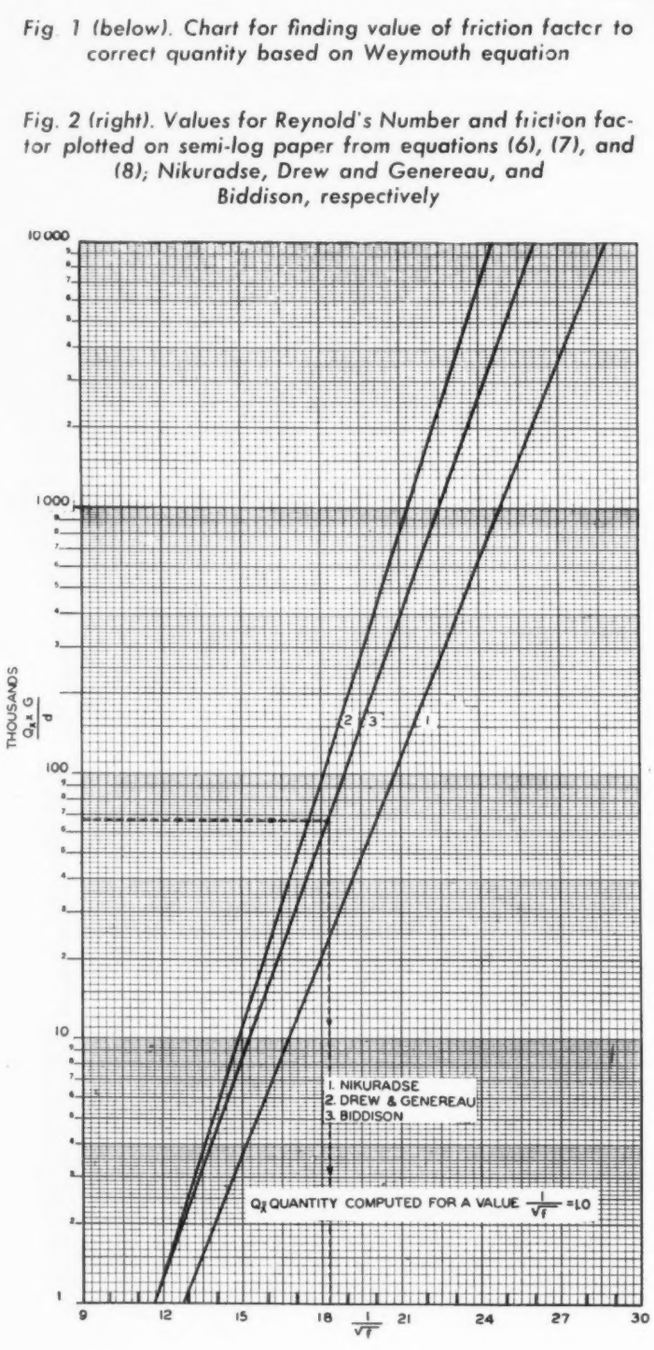
$$\frac{Q_x}{Q_w} = \frac{1}{11.18 d^{1/6}} \text{ or } Q_x = \frac{Q_w}{11.18 d^{1/6}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

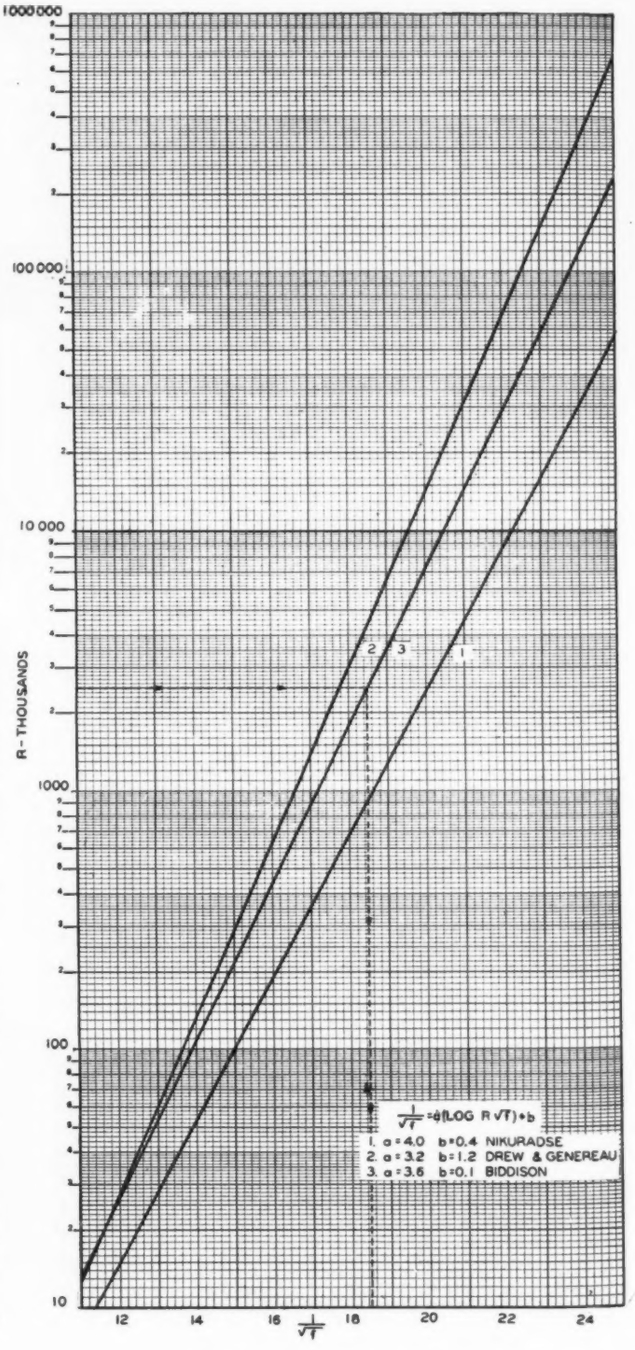
Viscosity

The viscosity of most natural gases can be expressed[2, 6] with but slight error in the ultimate results of a flow computation as:

Fig 1 (below). Chart for finding value of friction factor to correct quantity based on Weymouth equation

Fig. 2 (right). Values for Reynold's Number and friction factor plotted on semi-log paper from equations (6), (7), and (8); Nikuradse, Drew and Genereau, and Biddison, respectively





By improving equipment, applying new designs, J&L is increasing war-steel production

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FROM AN ORIGINAL DRAWING BY ORISON MACPHERSON

MEN OF SCIENCE AND SKILL EXPAND WAR-STEEL PRODUCTION

On the steel front the forward lines of production are backed up by the design-engineers and draftsmen, the maintenance men and construction crews. Scores of special engineers, in cooperation with experienced steel men, design new furnaces and develop mill improvements for increasing steel production. They coordinate their plans with the on-rushing future so that at the first opportunity, essential new work can be built with minimum interference to war-steel production. In the constant glare of adjacent furnaces, hundreds of riggers, welders, carpenters, bricklayers, pipe-fitters, electricians, men of a dozen crafts and trades, are working at a fighting pace building new steel-making facilities — rebuilding and improving others. Today, more steel than ever before — 85 million tons a year — is being produced to provide our fighting men with arms and equipment to crush enemy forces and to protect our own.

JONES & LAUGHLIN STEEL CORPORATION

PITTSBURGH, PENNSYLVANIA

CONTROLLED QUALITY STEEL FOR WAR

J&L STEEL

TABLE I

$\frac{Q_x \times G}{d}$	a = 4.0 b = — 0.4 Nikuradse smooth pipe	a = 3.2 b = 1.2 Drew and Genereau	a = 3.6 b = — 0.1 Biddison
100	8.746	8.517	8.131
1000	12.746	11.717	11.731
10000	16.746	14.917	15.331
100000	20.746	18.117	18.931
1000000	24.746	21.317	22.531
10000000	28.746	24.517	26.131
100000000	32.746	27.717	29.731

$$Z = \frac{7}{10^6} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

For this value of viscosity, the Reynold's Number for gases[2] is:

$$R = \frac{1.934 \times Q \times G}{d} \quad . \quad . \quad (13)$$

By dividing equation (1) by equation (9) we obtain:

$$\frac{Q}{Q_x} = \frac{1}{\sqrt{f}} \text{ or } Q = Q_x \times \frac{1}{\sqrt{f}}$$

. . . . . (14)

By substitution from equation (14) in equation (13):

$$R = \frac{1.934 \times Q_x \times G}{d \times \sqrt{f}} \quad . \quad . \quad (15)$$

By substitution from equation (5) in equation (14):

$$Q = Q_x \times (a \text{ Log } R\sqrt{f} + b) \quad (16)$$

By substitution from equation (15) in equation (16):

$$Q = Q_x \times (a \text{ Log } \frac{1.934 \times Q_x \times \sqrt{f} \times G}{d \times \sqrt{f}} + b) \quad (17)$$

$$Q = Q_x \times (a \text{ Log } \frac{1.934 \times Q_x \times G}{d} + b)$$

. . . . . (18)

Values of $(a \text{ Log } \frac{1.934 \times Q_x \times G}{d} + b)$ for

Various values of $\frac{Q_x \times G}{d}$ and for the three sets of values of a and b of equations (6), (7), and (8) are shown in Table 1 and are plotted on Fig. 1.

The method of use in solving for quantity is as follows:

(a) Determine Q_x by the Weymouth equation (2) and equation (11) or by equation (9). The use of equation (11) is simplified by Fig. 3, which shows the value of the friction factor of the Weymouth equation for any pipe diameter.

(b) Multiply the value of Q_x so found by G and divide by d. On Fig. 1 find $\frac{Q_x \times G}{d}$ on the left side and follow across horizontally to the line chosen as best fitting the friction factor of the problem; thence, downward to read

$$\frac{1}{\sqrt{f}}$$

at the bottom of the chart. Multiply Q_x by the value of $\frac{1}{\sqrt{f}}$ so found to obtain Q, the actual quantity of flow.

Example of Quantity Solution

Suppose we have found, by means of equation (2) or by means of a slide rule based upon the Weymouth equation, that for a line of 10-in. I.D., with gas of 0.60 specific gravity and with the other conditions of the problem, the indicated flow was 20,000,000 cu. ft. per day.

1. From Fig. 3 for 10-in. I.D. pipe, we find the value of $11.18 \times d^{1/6}$ to be 17.8.

2. Then, from equation (11):

$$Q_x = \frac{20{,}000 \text{ M. cu. ft.}}{17.8} =$$

1123.6 M. cu. ft.

3. From the specific gravity and pipe size of the problem:

$$\frac{Q_x \times G}{d} = \frac{1123.6\text{M.} \times 0.60}{10} = 67.416\text{M.}$$

4. From Fig. 1 for a value 67.417M. the corresponding value of $\frac{1}{\sqrt{f}}$ from Curve 3 is 18.30 using this figure in equation (14).

5. $Q = 1123.6 \times 18.30 = 20{,}562$ M. cu. ft.

If Q_x has been determined from equation (9) to be 1123.6 for same conditions of this problem, steps 1 and 2 above are not required and the solution follows steps 3, 4, and 5.

Example of Pressure Solution

For solution of equation (1), first find the Reynold's Number by equation (13). By reference to Fig. 2, find the corresponding value of $\frac{1}{\sqrt{f}}$. It will be found convenient to use this quantity as it is rather than to make a determination of f. With the value of $\frac{1}{\sqrt{f}}$ so found equation (1) may be solved on a slide rule.[2]

If, in equation (2), we have given the following conditions:

$Q = 20{,}000$ M. cu. ft. per day,
$T_o = 520°$ abs., $T = 520°$ abs.
$P_o = 14.735$, lb. per sq. in. abs.,
$L = 25$ miles, $d = 10$-in. I.D., and
$G = 0.64$
Then:

$$433.488 \times \frac{T_o}{P_o} \times d^{2\frac{2}{3}} \sqrt{\frac{1}{0.64 \times 520}} = 389{,}230.$$

From equation (2):

$$Q_w = 389{,}230 \sqrt{\frac{P_1^2 - P_2^2}{25}}$$

From equation (3) we may obtain:

$$Q_w = \frac{Q \times 11.18 \times d^{1/6}}{\frac{1}{\sqrt{f}}}$$

From Fig. 3 the value of $11.18 \times d^{1/6}$ for 10-in. pipe is 17.8. From equation (13) the value of R is:

$$R = 1.934 \times \frac{20{,}000 \text{ M.}}{10} \times 0.64 = 2476 \text{ M.}$$

From Fig. 2 for this value of R we find from Curve 3 that $\frac{1}{\sqrt{f}} = 18.40$

Then:

$$Q_w = \frac{20{,}000 \text{ M.} \times 17.8}{18.40} = 19{,}348 \text{ M.}$$

Use this value of Q_w on a Weymouth computer or by calculation:

$$19{,}348 \text{ M.} = 389{,}230 \sqrt{\frac{P_1^2 - P_2^2}{25}}$$

Square, rearrange, solve on slide rule:

$$\left(\frac{19{,}348\text{M.}}{389{,}230}\right)^2 \times 25 = P_1^2 - P_2^2 = 61700$$

If $P_2 = 50$ lb. abs. then $P_2^2 = 2500$
$P_1 = 248.4$ abs. $P_1^2 = 64200$

References

[1] "Flow of Natural Gas Through High-Pressure Transmission Lines," Johnson and Berwald, *Monograph 6, U. S. Bureau of Mines.*

[2] "Gas Flow Computations," P. McDonald Biddison, *Proc. Natural Gas Section, American Gas Assn.*, 1941.

[3] "Fluid Flow in Clean, Round Straight Pipe, B. Miller, *Trans. Am. Inst. Chem. Engrs.*, 33-474, 1937.

[4] "Relating Friction Factor and Reynolds Number," B. Miller, *Chem. and Met. Engr.* Vol. 44, No. 10, Oct. 1937.

[5] See discussion by Drew and Genereau of Reference 3.

[6] "Viscosity of Natural Gas," Johnson and Berwald, *Tech. Paper 555, U. S. Bureau of Mines.*

[7] "Forschungsheft," Nikuradse, 356-1932. Quoted by B. Miller in Ref. 4. See also discussion by Drew and Genereau, in Reference 3.

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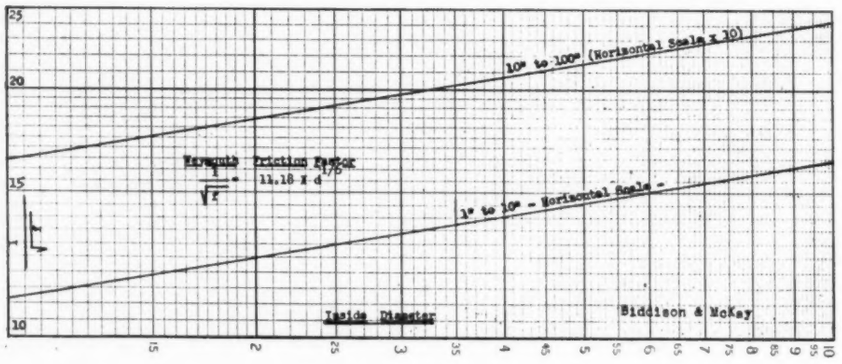


Fig. 3. Chart showing value of friction factor of Weymouth equation for any pipe diameter

Refinery Practice for the Operating Man

Vocational Class Proceedings in Refinery Engineering

Manufacture of Lubricating Oils

Class Meeting No. 9 (Continued)

NOTE: Throughout the class proceedings, no attempt is made to distinguish the identity of the pupil speaking. When a series of remarks is made by pupils it usually denotes an interchange of discussion among the class members themselves.

Leader: The next part of the lesson is a study of what is done with the extracts. This is a very important subject and is worthy of a great deal of study. Let us see how many good uses there are.

Pupil: You can always burn it.

Leader: Burn or use as a stabilizer for cracked fuel. Refer to page 166 of text, which indicates when blended with fuel oil retards sedimentary deposition; for example benzol gives a lower BS&W value than gasoline when used as a solvent for cracked fuel oil. Some of the processes we studied had a low yield of solvent oil and considerable oil went into extract.

Pupil: We can extract the extract and get a yield of cheaper grade oil.

Leader: Would such an oil be marketable?

Pupil: The author says it is.

Leader: He gave several examples and pointed out it should be possible to get a fairly good oil. Where could such oils be used; that is, oils with low viscosity index?

Pupil: For the lubrication of machinery.

Pupil: We found a use only today for this secondary oil in the making of aluminum base greases. The yield and appearance are better, too.

Pupil: The extracts are rich in aromatics and can be used as cracked stock.

Leader: Should they be considered a superior cracking stock?

Pupil: Yes, except in yield.

Leader: They are a superior cracking stock (aromatics).

Pupil: A lot of work is being done now with extracts for making plastic materials.

Leader: Yes, for plastics and resins.

Pupil: They can be used for explosives.

Pupil: And for road oil.

Leader: All in all, there are quite a few good uses.

Pupil: The gravity of this extract would be similar to tar, would it not?

Pupil: Our present tar is 13.4 and 13.6.

Leader: How are those determined?

Pupil: By alcohol-water solution.

Pupil: Could the extracts be blended and sold as commercial fuel?

Leader: Yes, but most commercial users are not required to use extremely viscous products.

Pupil: The B.t.u. content would be high.

Pupil: I am wondering about the melting point on the aromatic. What is the melting point? Is it considered liquid or solid?

Leader: It is considered a solid.

Pupil: It is used as a road oil. It will flow under some conditions but at zero temperatures, it can be walked upon.

Leader: I found some very interesting pictures of the effect of Paraflow. (Fig. 16.)*

(1) Photograph of paraffin crystals when carried to low temperature in motor oil with pourpoint of about 30.

(2) The same oil was taken and Paraflow added.

From the two photographs, what would you say has happened?

Pupil: The crystals are changed, smaller.

Leader: Would that lead you to the thought that you would probably get a bridgework between these crystals when you run the ordinary pourpoint on them? This may be solid at 30 and the other, not having the bridgework, will continue down to minus 10, as an example.

Pupil: The percentage of paraffin increases.

Leader: Yes, there actually is more.

Pupil: What happens to the viscosity index if you get the same pourpoint by using Paraflow rather than removing all the wax?

Leader: What would happen if all the wax was taken out by solvent process—virtually complete removal?

Pupil: I think you raise the viscosity index very slightly by using Paraflow.

Pupil: You lower it after dewaxing it.

Pupil: This is shown on pages 168 and 169 in the text.

Leader: Let's think about it just a moment. When you heat crude scale wax, how thick is it?

Pupil: About 31 or 32 sec.vis.

Leader: About like kerosine. Then heat to 300 deg.; what happens?

Pupil: It changes very little.

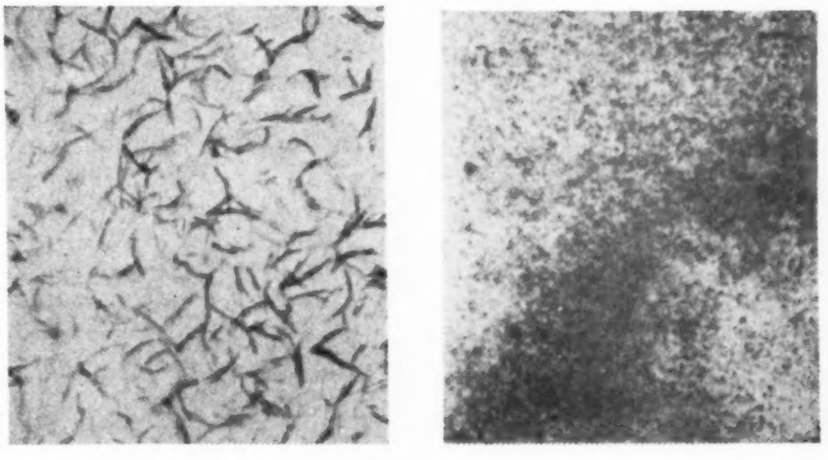
Pupil: You sacrifice viscosity.

Pupil: I suppose that wax increases the viscosity index provided the temperatures are taken at points where the wax is completely soluble in the oil.

Leader: An example is an oil at 200-210°F. that is soluble whereas at 100°F. it was not soluble.

National Petroleum News, April 19, 1939.

Fig. 16. Left—Paraffin crystals in untreated lubricant at low temperature. Right—After Paraflow was added



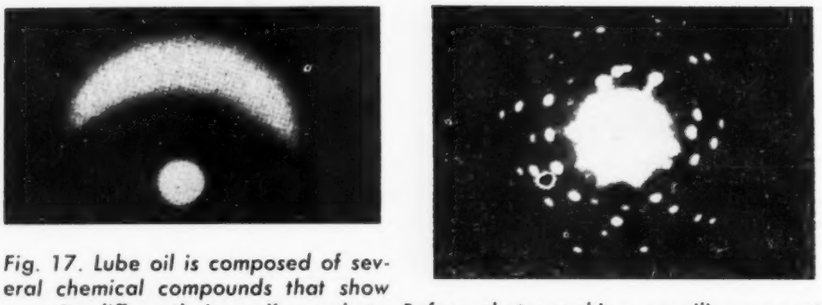


Fig. 17. Lube oil is composed of several chemical compounds that show up quite differently in an X-ray photo. Before photographing, an oiliness agent was added to the lube oil and wax was present. The crystal growth had not occurred when the photo at the left was taken. After the "halo" was scattered, the crystal arrangement was orderly in the manner shown in picture at the right

Pupil: You have a high viscosity substance dissolved in oil.

Leader: That statement is in favor of carrying the dewaxing to plus 10 pourpoint and leaving in the wax, which would not be so bad.

Pupil: The reason I said what I did about the Paraflow increasing the viscosity index is that Paraflow is a paraffin hydrocarbon attached to naphthalene so that if you are going to consider it from that standpoint, it comes to the question of solubility.

Leader: Paraflow has a very small amount of ingredient. The rest is to facilitate the solution in final blend.

Pupil: When taking viscosity index of oil containing either high or low melting point wax, which would have the better viscosity index number?

Leader: The lower melting point.

Pupil: Considering that they would be in solution, the higher melting point would then give the best viscosity index.

Leader: Some of the early investigators found that there are natural inhibitors to pourpoint but I think we will agree they are of poor stability and we will pass to the next phase, which is in recognition of the natural inhibitors and the bad things the investigators have found. We turn to synthetic sources and if we can judge by the patents obtained each year on the synthetics we can see a very wide field exists and will exist in the future. Two of those discussed in our text include Paraflow and Santopour. What is Paraflow?

Pupil: Paraffin wax hooked on to a naphthalene aromatic. When they join you lose the chlorine.

Leader: What are the characteristics of pourpoint depressants?

Pupil: 1. More effective with low viscosity oil.

2. More effective with low paraffinic oils.

3. Little or no effect in lowering the cloud point.

4. They impair the oxidation stability of the oil (especially turbine oil).

Leader: What is the pourpoint of Paraflow?

Pupil: Plus 20 on 100 percent.

Leader: On Santopour?

Pupil: Plus 10.

Leader: These depressants are being patented at the rate of from 10, 15, to 20 per year and, although their commercial significance is not notable, there are a number of variations.

Leader: In general appearance, the depressants are something like bright stock.

Pupil: In the tables given in our text, when they give the characteristics of Santopour and Paraflow, are those taken on commercial grades as sold in which the depressants are soluble in oil?

Pupil: Those characteristics are with the depressants in blend. They do not show the true characteristics.

Leader: Another interesting point is the discussion of the use of pourpoint depressants in the dewaxing process. This makes one think that perhaps we have not gone the limit in finding the causes for cloud in certain centrifuge products.

Pupil: What about the removal of the depressants?

Pupil: They can be removed by clay.

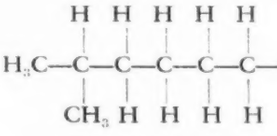
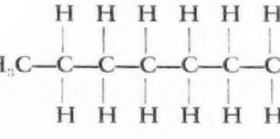
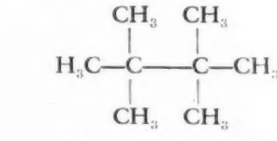
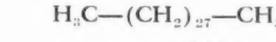
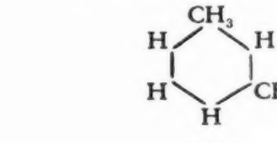
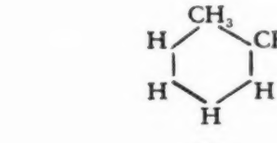
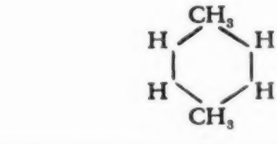
Leader: Some of the filters in automobiles make use of clay and may remove such agents.

Pupil: Many filters on automobiles do not use clay.

Leader: A few have clay; they are made by several concerns. Most of the

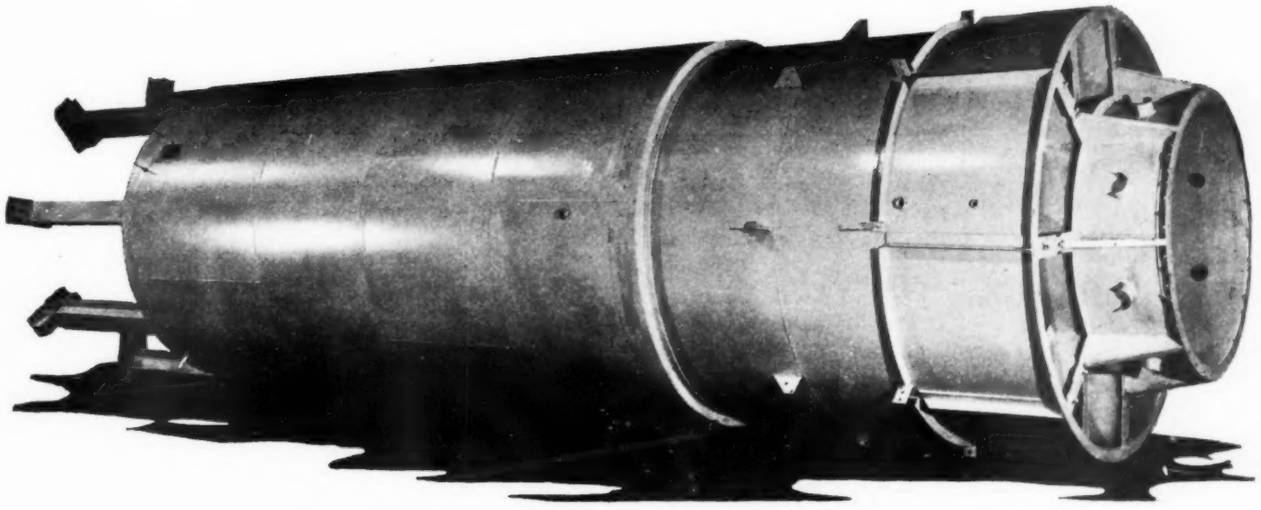
TABLE 13

Effect of symmetry on the freezing point of several hydrocarbons
By Frederick D. Rossini, *The Refiner and Natural Gasoline Manufacturer*, November, 1937.

Hydrocarbon	*Empirical formula*	*Structural formula*	*Freezing point (°C.)*
2-Methylheptane	C_8H_{18}		— 111
Normal octane .	C_8H_{18}		— 57
Hexamethylethane	C_8H_{18}		+ 104
Normal nonacosane	$C_{29}H_{60}$		+ 64
Metaxylene . .	C_8H_{10}		— 48
Orthoxylene . .	C_8H_{10}		— 25
Paraxylene . .	C_8H_{10}		+ 13

PREFABRICATED

. . . READY FOR ERECTION WITH A MINIMUM OF LABOR



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filters use waste cotton as their medium.

The following is a discussion of the relation of the structure of molecules composing lubricating oils and the effect of pourpoint depressants on these structures, as reported by one of the class members:

Those compounds that are believed to affect the pourpoint of the oil may be considered. Rossini's article (discussed at the last meeting) states that "the freezing point of hydrocarbon molecules is, for a given size of molecule, dependent (among other things) on the symmetry of the molecule, but not on the type; the greater the symmetry of the structure of the molecule, the higher the freezing point." Another article by Rossini states "that while large hydrocarbon molecules usually have higher freezing points than smaller ones, the effect of symmetry of the molecules on the freezing point is so marked that it is unsafe to draw any general conclusions." (See Table 13.)

As the refining process removes unsaturated compounds, the saturated compounds should receive greater consideration when discussing the action of pourpoint depressants.

Large interlacing crystal growths will cause an oil to cease flowing. This crystal formation depends on an orderly arrangement of the component molecules. The action of the pourpoint depressant is to modify the structure of the wax crystal (see text page 176).

A possible explanation of this power of modifying the structure of the wax has been attempted by considering the action of polar molecules. Polar molecules "contain an atom or group of atoms exhibiting secondary or residual valence." ("Fundamental Chemical and Physical Forces in Lubrication," by Clark, Sterrett, and Lincoln, *Refiner*, November, 1935.) These authorities have found that polar molecules do have a measurable effect on the arrangement of petroleum lubricating oils on the bearing surfaces, hence they are used to increase oiliness. They have determined the thickness of molecular layers and the number of layers in a given film. This was done by x-ray diffraction.

The accompanying sketches are given as they may be of possible interest. (Fig. 17.) If this effect of molecular arrangement on bearing surfaces can be attributed to residual valence, would it not be reasonable that residual valence would have unbalancing effect on wax crystal growth? The orderly arrangement of molecules in an oil film of course would not be expected to be the same as that in a wax crystal. The fact that a force is present that has the power of disrupting certain orderly molecular arrangements and replacing them with other orderly arrangements would be the basis for a proposed explanation for the action of pourpoint depressants.

As it is reasonable that there is a relationship between pourpoint depressant addion agents and oiliness agents, isn't it possible that the so-called natural inhibitors are related and that some similarity may extend to the other additional agents in popular use?

Pupil: Does he (Rossini) say anything about colloidal carbon as a pourpoint depressant?

Pupil: On this particular discussion, I have not looked up any particular one or any particular compound that would cause pourpoint depressants, but have studied only from the general standpoint and the theory behind what causes it.

Pupil: The quotation from the book on the use of an electrical charge should be some proof of Kohler's theory.

Pupil: Might not there be some connection between subjecting the oil to an electrical charge and the results we get by oil demulsibility?

Pupil: I have tried something along that same line.

Pupil: Oils are subjected to electrical charges over a period of time when trying out their demulsibility.

Leader: Unless you refute a theory you probably should accept it.

Pupil: The thing that confused me on the Kohler theory is the fact that a pole mole could distort the arrangement of polarity but at the same time you get a mole layer. If all the moles in the lubricating oil were the same type and you threw in a few aromatics, you would upset the entire arrangement. So far as we have gone here, I can't see any place where an aromatic would be good in lubricating.

Leader: This will bring us to the subject of the theory of good lubrication, and is a good indication of its importance.

Class Meeting No. 10

Leader: This is the meeting that we begin the discussion on lubrication. Who will begin the discussion with a few notes on the history of our subject?

Pupil: Lubrication as we know it today is more or less of a modern development. In attempting research on the history of lubrication, I found some interesting things that I should like to offer for your approval or disapproval. With your permission, I shall read the following:

In ancient times, the machinery that was needed for the lifting of water or weights, or for conveying loads, consisted of simple pulleys, windlasses, and sleds. These sleds were developed and became carts and wagons equipped with wheels and axles.

The bearings were rough, and, if lubricated at all, were probably packed with fats from bodies of animals.

A chariot found in a tomb and now displayed in the Cairo museum, still had some of the original lubricant on the axle. This chariot was used about 1400 B.C. This lubricant was analyzed as follows:

1. Road dirt such as quartz sand.
2. Compounds of aluminum, iron, and lime.
3. The substance was slightly sticky and slightly greasy.
4. It had a melting point of 121.5° F., which suggested mutton or beef tallow.

According to Pliny (A.D. 23-79) the "ancients" of his time had available and in use for various purposes the oils from about the same number and kind of seeds and plants as we have at present. They were also acquainted with several products from petroleum and oils from animals.

Primitive forms of machinery were lubricated with an occasional application of whatever lubricant was available, and conditions in this respect have not changed materially since the first machines were made. For many centuries after the beginning of the Christian Era, these conditions prevailed.

With the advent of the age of steam, the first commercial steam engines that operated early industrial plants were lubricated with beef tallow. The melted beef was fed by means of a tallow cup attached to the steam chest. The guides and main bearings were oiled with castor oil, or lard oil.

Large open bearings, in case of iron-rolling mills, were packed with beef or mutton tallow, or a side of pork. Hard tallow was mixed with red lead and used to lubricate the gears. Lard oil was the accepted lubricant for the machine-shop engine bearings, lineshafts, and tools. Lard oil was also used in lamps and torches, as a cutting oil, and for belt dressing.

Sperm oil and olive oil were used on the machines in the textile industry, as well as upon leather belts and in the lamps for illumination.

Petroleum

Petroleum has been known from the earliest times, its antiquity being indicated by use of bitumen in the cementing of tools by men of the late Stone Age. Herodotus (484-424 B.C.) indicated the ancient method of manufacture to produce bitumen and lighter oil.

Dr. James Young, in 1847, found petroleum in Derbyshire, England, from which he obtained a heavy lubricating oil by destructive distillation.

The opening of the Pennsylvania oil fields in 1859 provided a new source of crude oil supply for the American refiners operating under Dr. Young's

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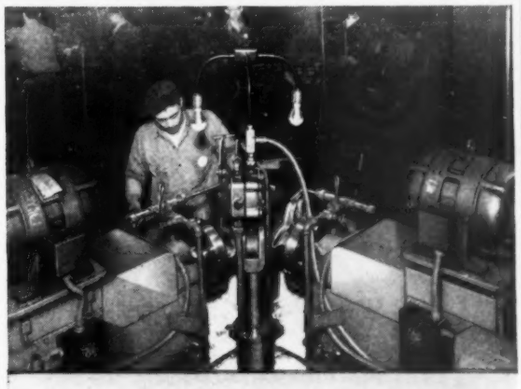
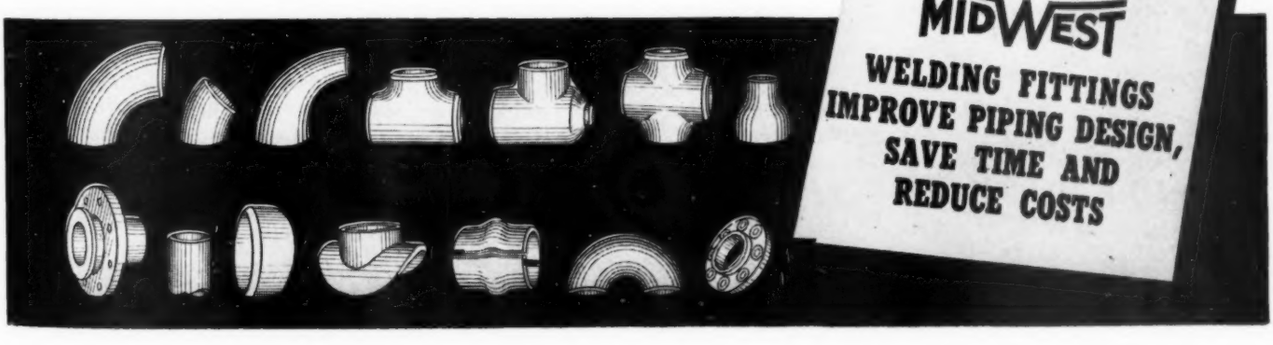


Shown here is one of the machines especially built by Midwest for simultaneously machine-beveling both ends of Midwest Welding Elbows and holding the included angle within extremely close limits. Special fixtures and special tools were also developed for this work. Similar machines with three heads are used for finishing Midwest Tees.



MIDWEST WELDING FITTINGS IMPROVE PIPING DESIGN, SAVE TIME AND REDUCE COSTS

patents. These refineries produced burning oils, and introduced lubricants, made as a by-product, to the manufacturing world. The development of mineral oil lubricants advanced rapidly after the discovery of oil, in Pennsylvania, as the fact that oil could be procured by sinking wells into the oil-sand was realized.

In 1883, Beauchamp Tower reported the results of his investigations of lubrication. He found that the best form of lubrication could be obtained by using an oil bath, when using lard-oil, rapeseed oil, and sperm oil, as well as mineral oil. This important report contained the following data:

Method of lubrication	*Coefficient of friction*	*Comparative friction*
Oil-bath	0.00139	1.00
Siphon lubricator	0.00980	7.06
Pad under journal	0.00900	6.48

In 1886, Osborne Reynolds established the fact mathematically that a well-lubricated journal, rotating at a fair rate of speed, becomes automatically separated from its bearing by a film of oil, under pressure, and that the frictional resistance is then due to the viscosity of the oil.

After reviewing the works of Reynolds and Tower, John Goodman stated in 1886 that the coefficient of friction with the surfaces efficiently lubricated is one-tenth that for dry or scantily lubricated surfaces.

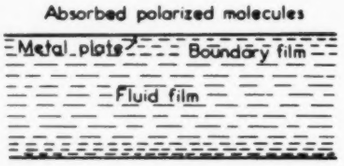


Fig. 18. Two metal plates into which the polarized oil film penetrates

The works of these eminent engineers established rules for the construction of machine bearings and their efficient lubrication. The lubrication of machinery may be divided into the general methods of application shown in Table 14.

Pupil: The statement, that the friction is directly proportional to the weight, led to some controversy. Is the friction proportional to the weight or to the area of contact? If you have comparatively rough surfaces between two metals, the greater the force pressing them together the greater the force required to slide these surfaces. Then, if the force pressing the surfaces together remains constant and they are polished so there is more contact area, the friction is apt to increase. Do you think that is logical?

TABLE 14

Method of application	Remarks
1. Hand-oiling	Poor results in regard to lubrication, as the gearing is alternately flooded and dry.
2. Pad-lubrication	The pad is situated under the journal, opposite the point of greatest pressure. The lubricant is carried to the bearing surface continuously by capillary attraction.
3. Siphon wick feed or drop-oilers	Slightly better results were obtained, as these oilers supplied oil to the film in small amounts at frequent intervals.
4. Bath lubrication	Only 1/10 the power required as compared to hand-oiling. This type of lubrication, and rapid development of mineral lubricants, made further advancement in machine construction and operation possible.
5. Gravity-feed circulating system	In this method, the oil is carried in a tank higher than the bearing, to which it flows in a restricted stream, and is then splashed around in the crankcase. Better results are obtained than with bath lubrication, as the bearings are continuously flooded with cool oil.
6. Force-feed lubrication system	In this system, the profuse quantities of the lubricant are fed under pressure, which can be made as high as required to assure complete flooding of the surfaces. Coolers, heaters, filters, and various other refinements have been added to this system of lubrication.

Leader: I don't believe that is true.

Pupil: I believe that with highly polished materials, the adhesive attraction is greater.

Pupil: I did not really mean to promote an argument on that point. The author* discussed the thin film friction and gave the different types of friction such as boundary, fluid, etc., and this thin film friction is the thing that present-day engineers are fighting and what they are eventually going to have to overcome or the present mechanical age is going to cease to develop any further.

Leader: Is one molecule thickness considered a thin film?

Pupil: I believe you are thinking of boundary lubrication and he is talking about boundary friction.

Pupil: I recall making the statement that thin film friction included everything less than 300 to 400 molecules thick.

Pupil: I think that is right. In this drawing (Fig. 18) we have two plates of metal and penetrating into these the polarized oil film. That is taking into consideration we are using polarized lubricating compound and then adjacent to the metal areas are layers of oil molecules attached to the metal.

Leader: Those are two metal surfaces separated by oil?

Pupil: Yes.

Pupil: I was wondering whether they were on the metallic side or on the oil side?

Pupil: It does not indicate in the drawing; however, I think that it would be any polarized molecule or any additive agent that would add to the oiliness of the lubricating fluid. As you know, there are a great number of these.

Pupil: What about the absorptive qualities — wouldn't they have to be brought out there; the degree of absorption?

Pupil: Yes, however, any polarized molecules will tie into this metal in that manner. The underlying theory of polarized molecules is to take care of the free ions on the surface of the metal.

Pupil: Isn't there a difference between boundary lubrication and boundary friction? In boundary lubrication you still have friction, but in friction you do not have lubrication.

Pupil: I did not mean to make that statement; I think you will still have lubrication, and I believe you will have your best lubrication.

Pupil: Then it is boundary lubrication rather than boundary friction?

Pupil: I don't know; probably some of both. You will always have friction. Lubrication is that characteristic of any substance that will decrease the coefficient of friction.

*"Modern Methods of Refining Lubricating Oils," by V. A. Kalichevsky.

(To be continued)

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A New Conception of Acidizing

PART 2 (Continued)

by C. E. Clason

Superintendent Acidizing, Halliburton Oil Well Cementing Company

AS an example of acid action consider a case in which horizontal fractures alone are involved. The formation is an average limestone and the reaction time to place the acid is assumed to be 50 minutes.

100 fractures—0.01 mm., or approximately 0.0004 in. wide. 1000 gal. to fill these fractures would be forced out laterally to a radius (R) of 112 ft. 7 in. This is an increase of 21.2 percent and means 45.0 percent increase in flowing capacity, which is proportional to the square of the increase in width (W) at the well bore.

For 2000 gal., R = 141 ft.
For 4000 gal., R = 225 ft.
For 8000 gal., R = 315 ft.

Successive stage treatments pumped in the same time would result in approximately 21.2 percent increase in channel size near the well bore for each, so that two different stages would more than double the flowing capacity. The effect of pumping time and its relation to reaction time will be considered more in detail later.

In an extreme example of this sort, it should be realized that the limestone has a certain permeability and effective porosity aside from those of the crevices considered. Enlargement of the crevices therefore enlarges the channels or conduits of the system as a whole toward the well bore. The net result can be an increase in production of 200 or 300 times that of the original. More efficiency will result from enlarging the drainage area, because oil and gas will be drawn from a greater distance around the well bore by virtue of less potential energy being required to move the oil and gas through the formation to the bore of the well. Such a well could be treated with a greater volume of acid than another well whose pay formation is the same thickness but of uniform permeability and porosity, before the economic limit was reached. That limit is reached when a further treatment would produce only a slight increase in radius of penetration compared with the enlargement of the crevices and result in no greater volume of production. In areas where formations respond favorably to acid treatment such as just discussed, wells could be spaced farther apart than usual after it was proved that production could be increased by this method.

Effective penetration of a formation obtainable in practice will be between that of the type just discussed and that calculated for porosity alone, such as illustrated by Figs. 1 and 2.

Large increases in production may be obtained when the normal permeability is obscured by mud or other deposit, condition that accounts for treatment with a small volume of acid giving abnormal results.

Two extremes in figuring penetration of acid have been considered. Removal of limestone by acid follows the same qualitative rule with respect to cone-shaped channels, regardless of the rate of reaction. Variations in radius of penetration might result from varying width, or varying diameter if a round channel is considered. Velocity of flow of oil or gas will be greatest at the well bore. The conditions of flow have been altered because a greater pressure drop has been established in the last few feet of travel of the oil or gas into the well by virtue of the resistance to flow having been decreased.

Due to greater enlargement of channels or fissures near the well bore, either from single or successive stages of treatment, sediment and insolubles are more easily expelled and washed from the well. New cross channels are opened and constrictions removed, so that in many cases a new source of confined oil or gas is liberated.

In our example of penetration in fractures, 8000 gal. would penetrate 315 ft. if 100 fractures 0.0004 in. wide were taken. This width is quite typical for limestone. If there were 200 fractures, the penetration would be only 79 ft. and if 400 slightly under 20 ft. This last corresponds to 8000 gal. in about 8 ft. of uniformly permeable pay of 10 percent porosity. It is somewhat speculative to state how many fractures will be encountered and exactly what width, and how much effective porosity and uniform permeability will be encountered in a given depth of open hole. Later in this article, the method will be discussed that will give an indication of the type of formation undergoing treatment.

Enough is known about oil-producing limestone formations, however, to state that most are closer to those in the porosity curves shown in Fig. 1 than otherwise. Only occasionally are formations found in which the production is from lateral cracks, and some of these are produced by water drive. Vertical permeability is also present, so that large volumes of acid are likely to penetrate in all directions outwardly, vertically as well as horizontally. It is not practical to try for great penetration if the water table is close; in fact, smaller treatments will accomplish more in this type of formation, of which the Arbuckle in Kansas and some of the Glen Rose series in Texas, Louisiana, and Arkansas, are examples.

All other formations in limestone, except for a few isolated cases in some pools, are producing oil entrapped and confined with gas. Accompanying water is incidental and not a factor in driving oil to the well. Gas fields of the Panhandle and Southwestern Kansas areas are in this category. The limestone is more granular in texture as a rule, where initial production is at all prolific, and hence in producing characteristics is more closely comparable to sandstone than limestone. Wells of small initial production have been proved to produce from crevices or small channels, having been increased by acidizing to produce 30 or 35 times the original volume. The curves in Figs. 1 and 2, although they apply only to the average well, have some value. They indicate that, unless a large volume of acid is forced into relatively thin strata or into crevices of narrow width, acid penetration is not as is commonly visualized.

Drainage area is limited in this first type of formation to a given area for each well. In formations where a strong water drive is present, 80 to 90 percent of the oil in the pool may eventually be produced, but this is not true of the other type. The extent of this drainage area must be found by experiment and in some instances is never known until five-spotting or some other well pattern is adopted or repressuring is established at a later time. Obviously, with as little penetration as is indicated, the prospect of increasing the drainage area of the well is slight, even when large volumes of acid are used and particularly if the pay sections are of considerable thickness. More can be accomplished by selective acidizing of various pays to obtain greater production,

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If the formations of all limestone fields were of a normal but uniform permeability and porosity, had the same rock pressure, and were equally soluble in acid, a volume of acid to obtain the greatest efficiency for increased production could be computed for any thickness of pay strata. But limestones vary in all the characteristics just enumerated, so it has been customary to use data based on experience and results in a given field to substantiate a prescribed volume of acid for well treatment. Sometimes blind decisions are made, and the results prove that too much acid has been used. Methods will now be discussed that should provide a satisfactory basis of procedure in acidizing that may not only prevent the use of too much acid, but also indicate possible results that would justify the use of still more acid for a given well.

Acidizing Gas Wells

Gas well acidizing is described first because of the ease of checking results after treatment. The practices discussed, with the exception of water washes, are also applicable to oil wells.

Certain procedures are common to specific gas fields or areas. These procedures have been worked out and are based upon calculations and reasoning, plus experience.

The main procedure in the Hugoton and Panhandle areas is to give one or more small mud-cleanout shots with a weak acid solution preliminary to initial treatments with larger volumes of acid. Water is injected between stages to aid in washing-out insolubles and for diluting spent acid so as to accomplish its quicker and better removal.

A compressor and measuring line float, or Echometer, is used to displace and measure the acid injection when using gas as a pressuring medium. A water load with the well tubed and the gas-lift principle of unloading is also used. Both penetrating acid and gypsum retention are applicable to this work, as well as water for washing purposes treated with one-half the amount used to make penetrating acid.

In other areas, such as the chalk gas production fields near Monroe, Louisiana, gas pressuring alone is used, as water seems to have a plugging effect on the formation. Other types of formation producing gas in Louisiana and elsewhere can undoubtedly benefit from the washing process, especially if the rock pressure is less than 500 lb., but great enough to unload the well.

Washing the Well

Washing the well with weak acid can be done as the first stage of any treatment. The mud on the wall of the hole is flocculated by the weak acid and removed by the wash. In some instances, two washes may be advisable. No great penetration is desired nor needed at this first stage of the treatment.

Washing after a strong acid treatment should be done with water only, preferably treated to reduce surface tension if plain acid has been used.

When strong acid is pumped into a low-pressure formation and the head of fluid is forced down by a gas compressor to a point about 1800 ft. from bottom, carbon dioxide evolved from the reaction begins to come out of solution. Evolution of gas in this manner interferes with acid injection because of the resistance set up. It interferes also with reversing the flow of the well. The farther spent acid is pushed back into the formation, the longer it takes to return to the well bore. This is a result of so-called Jamin action, which occurs with carbon dioxide gas when the induced pressure or the formation pressure is less than 800 lb. per sq. in. Formation gas can also lead to Jamin action and delay the return of the spent acid to the well bore.

A large volume of weak acid put into a well initially would cause more trouble in this respect than a stronger acid, as bubbles would be formed without much removal of limestone or enlarging of the channels.

When gas has worked back to the well bore because of high formation pressure, quantities of fluid are bypassed. This is bound to occur, for the flow channels increase in size toward the well bore. When a well is allowed to flow, there will be a mixture of gas and fluid—evidence of what has happened. Such by-passing promotes evaporation, which tends to concentrate the spent acid solution, causing greater precipitation of gypsum than usual, unless it has been taken care of chemically and even then, a lowering of water content can cause some precipitation. From experience it is known that some of the solution remains in the pores of the formation. A water wash is all that is necessary to assist in diluting and removing these materials, but to be effective, the wash water should be pushed back almost as far as the previous acid. This means volume of wash water should equal volume of acid previously used.

There is no reason for overblowing a well after a strong acid charge. A point will be reached where evaporation will be going on in the formation while the gas is still wet. If the most of the spent acid is out, a water wash should follow and then more time taken to blow-out and dry-up the gas. The water will dilute any strong spent acid left and it should come out in less time than it took the heavier undiluted spent acid solution.

When a compressor is used in treating, more time may be required for displacing the acid from the pipe than when using water and pumps, and surplus water behind the acid will consume more time in forcing the acid into the formation. If too much time is consumed it will result in pushing spent acid ahead; and if only a small amount of water is used as a wash-up following the acid, only the sections of the channels nearest the bore of the well are washed, but farther back, where the acid has been forced, there will be no washing. There have been cases in which a well did not begin to flow for a considerable period of time after an injection. This is due to spent acid being forced out into the formation without increasing the size of the small channels and conduits, thus failing to reduce resistance and creating Jamin action that the formation pressure must overcome. The lower the formation pressure, the longer it will take for the fluid to return to the bore of the well.

A volume of wash water equal in amount to that of the strong acid charge should return as easy as, if not easier than, the spent acid. The carbon dioxide evolved from reaction under reduced pressure, creates a Jamin action, but the water does not, for there is no chemical reaction with water. Some Jamin action is created by bypassing of formation gas before the water is pushed back, although the extent will be less than when acid is used.

Originally, gas wells were acidized without use of water-washing. The first thought in regard to this was to aid in the removal of the spent acid. Then it was noticed that the water itself was muddy upon emergence from the well. This mud was precipitated gypsum and insoluble parts of the channel walls that were liberated by action of the acid. Some of these solids would lodge in the narrower, restricted channels away from the well bore. Small water washes remove only spent acid pushed forward by action of the formation pressure, necessitating an extra washing.

It is very apparent from Muskat's calculations that large increases in production from either an oil or gas well are due to one of two things: Either the permeability before acidizing is very much below normal near the well bore, or there are crevice conditions that allow greater travel of the acid. Muskat has shown that if the normal permeability of a formation were increased ten times through a certain radius from the well bore, the increase in production over the original would be only 170 percent for a radius of 50 ft.; 120 percent for 25 ft.; 80 percent for 10 ft.; 20 percent for 1 ft., and 9 percent for

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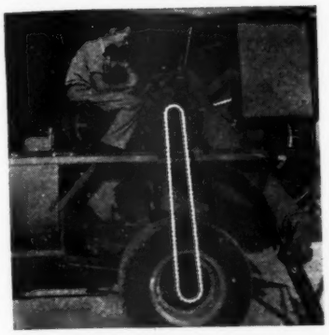

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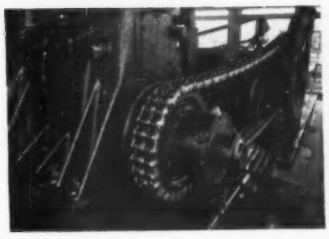

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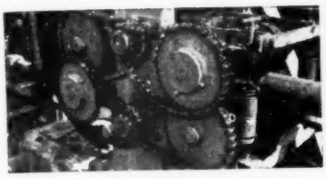
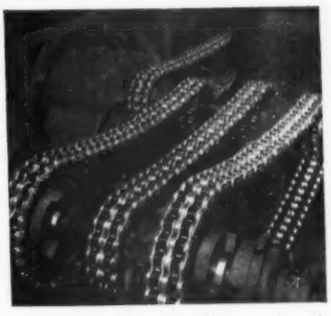


Pipeline cleaning and coating machine



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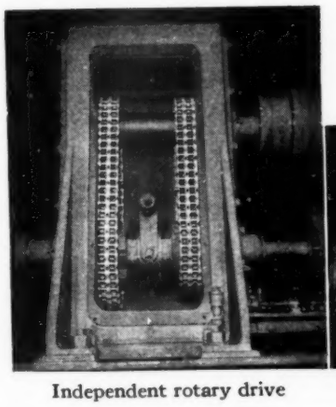

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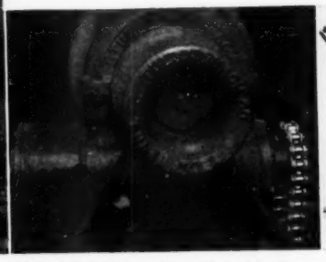

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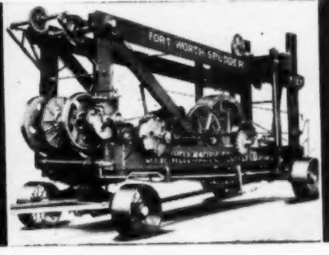

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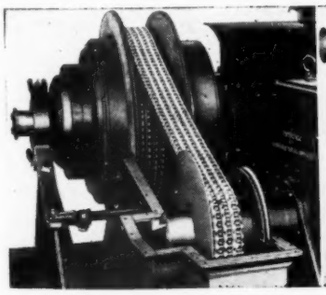
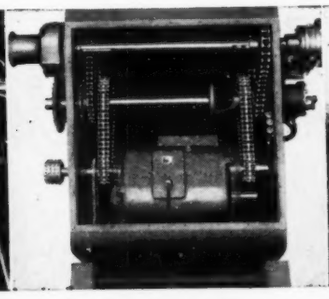
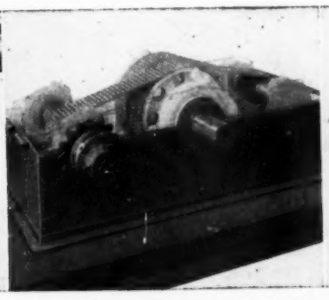


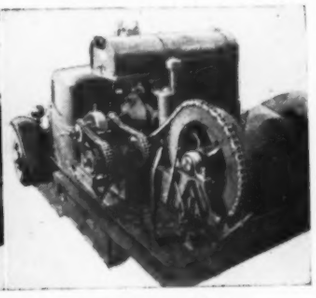
Torque converter drive



Light drawworks



Heavy duty transmission drive



Clean-out machine

LINK-BELT *Silverlink* ROLLER CHAINS

NAVY NEEDS MEN FOR OIL REHABILITATION WORK

The Navy has a limited number of billets for outstanding men in the petroleum industry whose chemical engineering background combines experience in the design of refinery equipment and the manufacture of fuels and lubricants. A good knowledge of blending and refinery control is highly desirable. These men will be used to help solve one of the toughest supply problems of the war.

Gasoline and fuel oil are two vital cogs in the Allied war machine, but transporting these materials over vast expanses of enemy-infested waters is difficult, complicated by the susceptibility of these carriers to enemy attack. Petroleum sources must be developed closer to the actual theaters of war operations.

Deposits of good crude oil exist, both in territory now controlled by the Allies and in lands that may presently be occupied. Wherever that potential exists, the Navy will employ the famous Seabees for reconstruction and rehabilitation of production and refining facilities. For experienced direction of these important jobs capable men in this field will be commissioned directly from civilian life.

Successful candidates will be given indoctrination and instruction to familiarize them with Navy bunker-fuel, Diesel-fuel, and gasoline requirements. They will then be assigned to duty with the Construction Battalion as planners and technical advisors in the refining of fuels for military use.

Men with the necessary qualifications can make an important contribution to the war effort and, at the same time, obtain valuable field experience in new areas of petroleum operations. For further information contact the Office of Naval Officer Procurement in your nearest major city, or write directly to the editor of this publication.

6 in. (See Fig. 4.) From a consideration of the total thickness of pay and the volumes of acid used, most instances of a greater increase than 50 percent for an initial treatment point to the permeability before acidizing being much below normal near the well bore, a condition predominant in oil and gas wells.

According to Muskat's determinations, if a 6-in. hole were underreamed to 18 in. diameter, only a 9 percent increase in production could be expected, provided the original hole was clean and not mudded-off or clogged with paraffin. It can be shown that an increase of more than ten times the permeability gives a very small increase in production. Assuming an increase in permeability of 10 times the original as a maximum, Fig. 4 shows the expected or theoretical increase in production at various distances from the well bore.

It would appear then that in gas wells the first washing to remove mud plus the smaller initial strong acid charge with its accompanying wash outward to the same extent as the acid, should restore the permeability at least to normal, provided the initial charge of acid was sufficient to penetrate the permeable pay sections for only 2 or 3 in. If the next larger charge of acid produced an abnormal increase of 50 percent or more, it would indicate crevice conditions, provided efficient penetration was obtained in the initial charge. If that were the case, it would suggest a third treatment with a larger volume of acid.

Proper washing and acidizing with increasing volumes of acid in stage treatments, and close checking of flow tests, should determine whether it is possible to obtain more gas or to make still larger wells that would pay for the increased quantity of acid necessary. Checking flow tests after each washing throughout the treatment will indicate the type of formation being treated. It is advisable to have detailed knowledge of the pay strata if it is available in order to compute the probable penetration of acid charges. Uniform porosity and a homogeneous permeability can be assumed pending a check on performance. If crevice conditions do not prevail, the treatment can be discontinued before too much acid is used, for results will indicate the procedure that should be followed. The treatments can be made on a volume scale, figuring displacement ratios to increase the radius for each succeeding charge.

A treatment, using a compressor, could be scheduled as follows: Check open flow of well; then place 500 gal. or the proper amount of 5 percent acid in the open hole and blow out into the air for 3 to 4 hours; flocculates and removes mud. In some cases, two treatments may be made. Check again for open flow and then displace 1000 gal. of 15 percent acid from the well bore. Blow for 3 to 4 hours, and then displace 1000 gal. of water from well bore. The well can be blown until the gas is fairly dry. Check increase in open flow. In the next stage, treat with 4000 gal. of 15 percent acid, followed by 4000 gal. of water used in the same manner as a wash, separately, allowing a longer time for blowing-out. Check again and if a 50 to 100 percent increase is obtained over that which the well showed after the last weak acid wash, it appears favorable for a larger and additional treatment. A volume of 8000 gal. would penetrate the formation 40 percent farther than 4000 gal., and approximately 8000 gal. of water should be used in washing. Again check open flow. If the flow is 25 to 100 percent or more than the preceding treatment, it would certainly indicate that crevice conditions exist and a still larger stage treatment could then be applied. A treatment of 12,000 gal. would penetrate at least 40 percent farther than the previous 8000 gal. for the same conditions in the pay and should be washed with 12,000 gal. water. It is problematical where such a procedure would end, as this would make a total of 25,0000 gal., yet it is conceivable that a total treatment of 50,000 gal. would be feasible in some wells if the method is used as described.

If the pay thicknesses and porosity are known and permeability is assumed to be uniform, the volume of acid can be calculated for the washing and the first stage to insure penetration will be sufficient to restore permeability to normal. The second stage treatment will increase drainage distance radially and will be another point on the yardstick to indicate the type of formation. If the third stage of treatment does not produce an increase above normal for the radial distance of penetration first calculated, conditions would undoubtedly be more reliable as calculated and a larger volume of acid would be wasted.

This method of procedure should be a distinct advance in answering the question of how much acid to use in treating. The theory behind this procedure is also applicable to oil wells. Water washing in a formation containing oil is unnecessary.

It will be noticed that the sequence of stages is given as 1000, 4000, 8000, and 12,000 gal. Beginning with 1000 gal., which would be a reasonable figure for almost any gas well in the areas referred to, a minimum penetration will be obtained when there may still be some mud to remove.

To penetrate twice the distance, 4000 gal. of acid is required. To penetrate twice the distance again, 16,000 gal. would be necessary, although it is believed that with half the volume enough increase can be obtained to indicate further procedure. If the results are unfavorable some acid and costs will have been saved. Stages of treatment of the size just discussed are given as examples pertinent only to a given area. The initial size of treatment will depend on well size and pay thickness.

(To be continued)

☆ ☆ ☆

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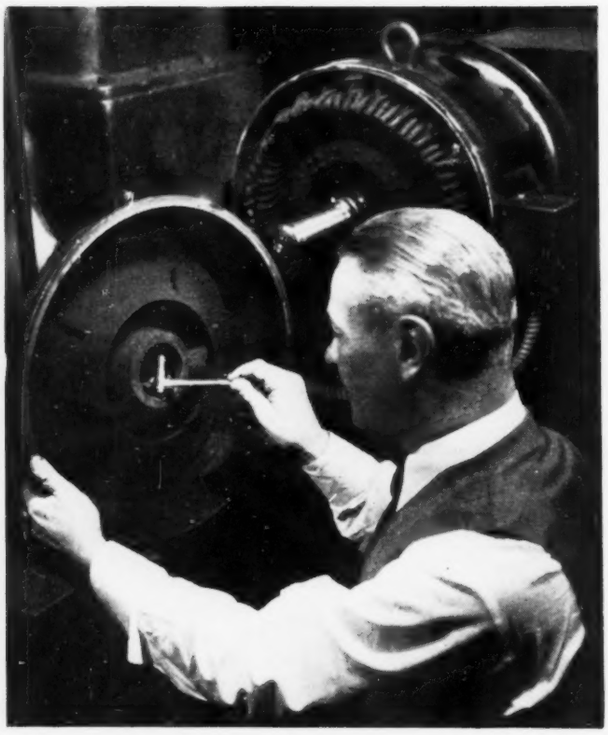
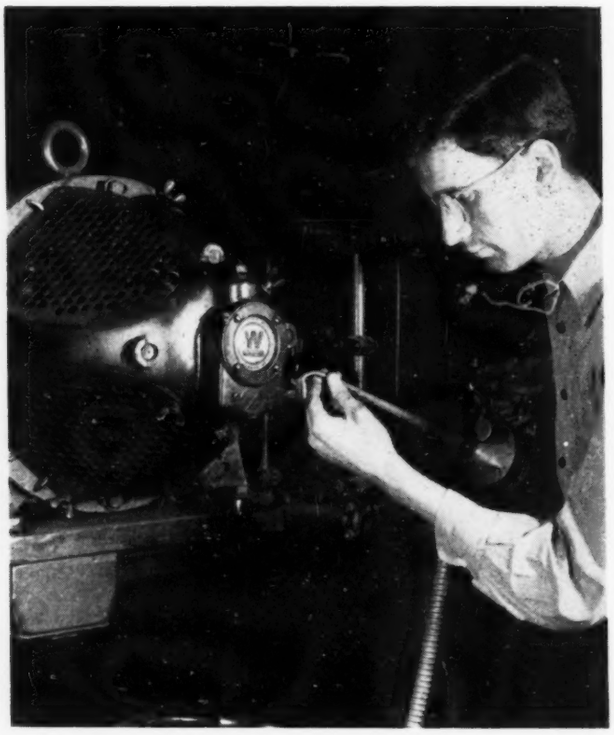


Eleven years of severe service show a bearing wear of less than 15/10,000 in.—due to proper lubrication and intelligent maintenance



Oiling the motor regularly is essential to long bearing life. Too much oil may contaminate the motor windings, causing possible deterioration of insulation

Maintaining Electric Motors and Generators

PETROLEUM ENGINEER Exclusive Feature

PART 2 (Concluded)

by *E. H. Lamberger*, Petroleum Engineer, and

W. W. McCullough, Maintenance Repair Engineer

Westinghouse Electric and Manufacturing Company

Insulation

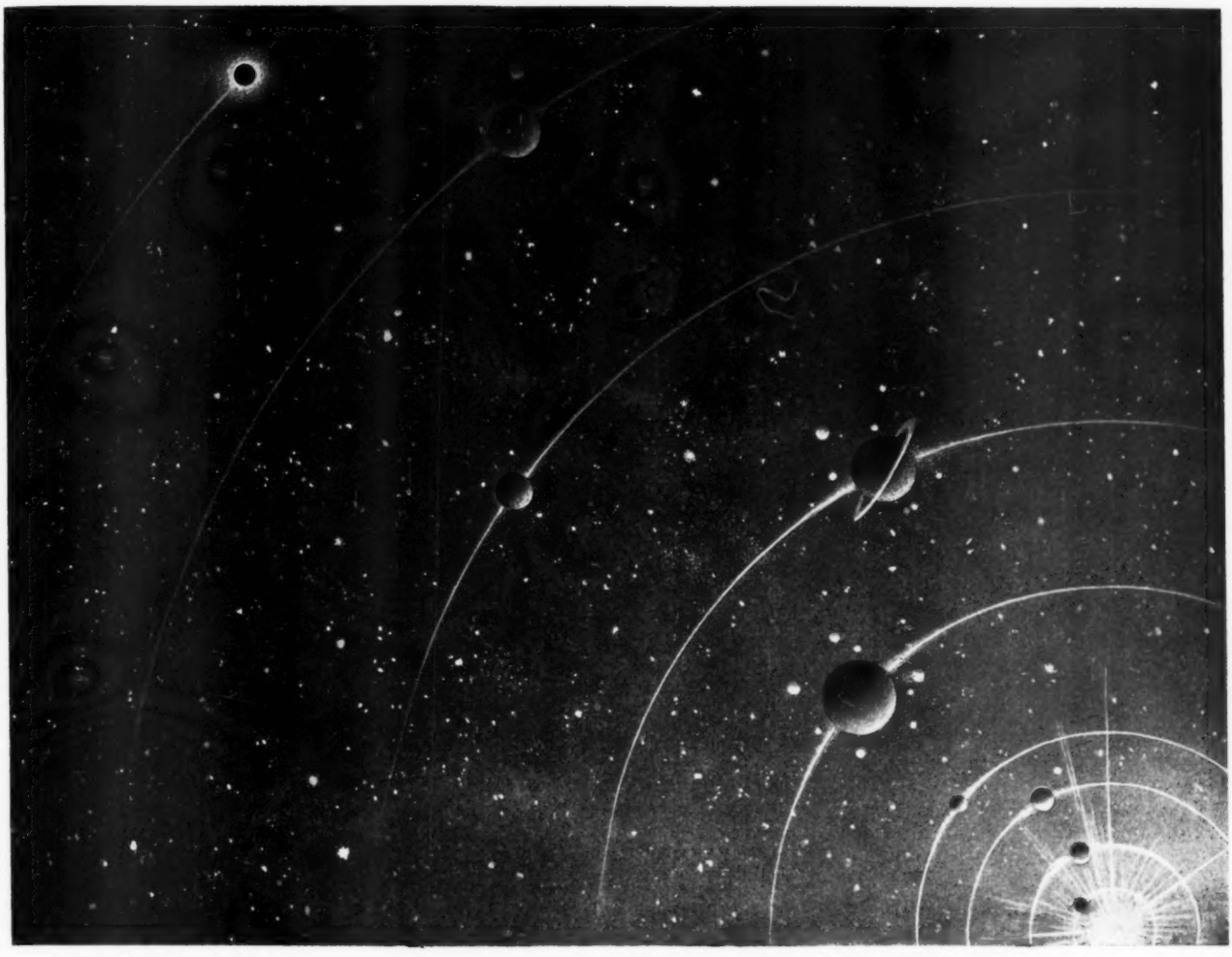
The electrical conductors in a motor are separated from the magnetic circuit and from the mechanical assembly by materials generally grouped under the term "Insulation." Insulation is also used in commutators to separate the bars from each other, and to isolate individual turns of a coil. It is essential that the insulation valve be maintained. Regardless of the class of insulation used, remember that electrical insulation materials are non-conductors only when clean and dry.

The importance of keeping electrical equipment clean and dry is always worth stressing. Accumulations of dust and dirt not only contribute to insulation breakdown, but they operate to increase the motor temperature through restrictions of ventilation. Dust and dirt are effectively removed with compressed air at about 50-lb. pressure. Do not direct compressed air against the insulation until certain that it is free from moisture that may have accumulated in the air line from condensation. Too great an air pressure may loosen the binding tape or injure the insulation by sand blasting with the abrasive dirt that is nearly always present. It may not be possible to remove all dust and dirt by blowing with compressed air. If the accumulation of dirt contains oil or grease, a solvent will usually be required to remove it.

There are three types of solvents in general use for this purpose. These are petroleum distillates, such as Stoddard solvent or cleaner's naphtha, carbon tetrachloride, and a mixture of the two. The petroleum distillates are the solvents having the least corrosive action on insulation varnish, and for that reason are preferable to the others where conditions permit. The Stoddard type solvent, produced by all the major oil companies, with a minimum flash point of 100°F., minimizes the fire hazard, and should be used in preference to gasoline or benzene. Every precaution should be taken to prevent fires or explosions.

When this type of solvent will not properly clean the apparatus a mixture of carbon tetrachloride and the solvent may be used. A mixture of 50 percent carbon tetrachloride and 50 percent Stoddard solvent is non-inflammable, but the vapors mixed with a right proportion of air are explosive. In extreme cases it may be necessary to use straight carbon tetrachloride; however, the toxic effect of this material on the operator must be taken into consideration.

Carbon tetrachloride is more corrosive in its action than petroleum solvents, and it evaporates much more rapidly. For this reason, the residue of



Is Pluto the Last of the Planets?

Nobody knows. It is dangerous to predict a limit in any field of research or science. The very mysteries of space—substance—energy—life—are forever quickening the human impulse to new explorations. . . . And yielding new discoveries!

Take the energy we call *power*. Successively through its journey out of darkness, the world has seen power wrung from the muscles of man and beasts of burden—from winds and from waterfalls—from steam, electricity and chemistry.

Momentous are the developments in the chemistry of petroleum. Even when it seemed that we had reached the last of its contributions to power which could be harnessed to do man's bidding, new reactions and refinements have been perfected to heighten the usefulness of petroleum's God-given elements

Badger engineering is in the thick of this progress—designing, building, improving and speeding equipment for the processing of both old and new products of the petroleum industry. Toward more power for planes, trucks, tanks and other war machinery, Badger is currently constructing large and small plants for the production of high-octane gasoline.

Also in Badger's capable hands is the building of plants for the manufacture of butadiene, toluol, alcohols, explosives, acetic acid, phthalic anhydride and other chemical products.

From these stores of experience are coming still greater Badger facilities for helping industries to fight the battles of competition in the readjustment era which lies ahead.

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TABLE 4

Trouble correction chart for d-c. motors

CAUSE	WHAT TO DO
TROUBLE: *Fails to start*	
Circuit not complete.	Switch open, leads broken.
Brushes not down on commutator.	Held up by brush springs, need replacement. Brushes worn out.
Brushes stuck in holders.	Remove and sand, clean up brush boxes.
Armature locked by frozen bearings in motor or main drive.	Remove brackets and replace bearings or recondition old bearings if inspection makes possible.
Power may be off.	Check line connections to starter with light. Check contacts in starter.
TROUBLE: *Motor starts then stops and reverses direction of rotation*	
Reverse polarity of generator that supplies power.	Check generating unit for cause of changing polarity.
Shunt and series fields are bucking each other.	Reconnect either the shunt or series field so as to correct the polarity. Then connect armature leads for desired direction of rotation. The fields can be tried separately to determine the direction of rotation individually and connected so both give same rotation.
TROUBLE: *Motor does not come up to rated speed*	
Overload.	Check bearing to see whether in first class condition with correct lubrication. Check driven load for excessive load or friction.
Starting resistance not all out.	Check starting to see whether mechanically and electrically in correct condition.
Voltage low.	Measure voltage with meter and check with motor name plate.
Short circuit in armature windings or between bars.	For shorted armature inspect commutator for blackened bars and burned adjacent bars. Inspect windings for burned coils or wedges.
Starting heavy load with very weak field.	Check full field relay and possibilities of full field setting of the field rheostat.
Motor off neutral.	Check for factory setting of brush rigging or test motor for true neutral setting.
Motor cold.	Increase load on motor so as to increase its temperature, or add field rheostat to set speed.
TROUBLE: *Motor runs too fast*	
Voltage above rated.	Correct voltage or get recommended change in air gap from manufacturer.
Load too light.	Increase load or install fixed resistance in armature circuit.
Shunt field coil shorted.	Install new coil.
Shunt field coil reversed.	Reconnect coil leads in reverse.
Series coil reversed.	Reconnect coil leads in reverse.
Series field coil shorted.	Install new or repaired coil.
Neutral setting shifted off neutral.	Reset neutral by checking factory setting mark or testing for neutral.
Part of shunt field rheostat or unnecessary resistance in field circuit.	Measure voltage across field and check with name plate rating.
Motor ventilation restricted causing hot shunt field.	Hot field is high in resistance. Check causes for hot field, in order to restore normal shunt field current.
TROUBLE: *Motor gaining speed steadily and increasing load does not slow it down*	
Unstable speed load regulation.	Inspect motor to see whether off neutral. Check series field to determine shorted turns. If series field has a shunt around the series circuit that can be removed.
Reversed field coil shunt or series.	Test with compass and reconnect coil.
Too strong a commutating pole or commutating pole air gap too small.	Check with factory for recommended change in coils or air gap.
TROUBLE: *Motor runs too slow continuously*	
Voltage below rated.	Measure voltage and try to correct to value on motor name plate.
Overload.	Check bearings of motors and the drive to see whether in first class condition. Check for excessive friction in drive.
Motor operates cold.	Motor may run 20 percent slow due to light load. Install smaller motor, increase load or install partial covers to increase heating.
Neutral setting shifted.	Check for factory setting of brush rigging or test for true neutral setting.
Armature has shorted coils or commutator bars.	Remove armature to repair shop and put in first class condition.
TROUBLE: *Motor overheats or runs hot*	
Overloaded and draws 25 percent to 50 percent more current than rated.	Reduce load by reducing speed or gearing in the drive or loading in the drive.
Voltage above rated.	Motor runs drive above rated speed requiring excessive horsepower. Reduce voltage to name plate rating.
Inadequately ventilated.	Location of motor should be changed, or restricted surroundings removed. Covers used for protection are too restricting of ventilating air and should be modified or removed. Open motors cannot be totally enclosed for continuous operation.
Draws excessive current due to shorted coil.	Repair armature coils or install new coil.
Grounds in armature such as two grounds which constitute a short.	Locate grounds and repair or rewind with new set of coils.
Armature rubs pole faces due to off center rotor causing friction and excessive current.	Check brackets or pedestals to center rotor and determine condition of bearing wear for bearing replacement.
(a) Hot armature	
Core hot in one spot indicating shorted punchings and high iron loss.	Sometimes full slot metal wedges have been used for balancing. These should be removed and other means of balancing be investigated.
Punchings uninsulated. Punchings have been turned or band grooves machined in the core. Machined slots.	No load running of motor will indicate hot core and drawing high. No load armature current. Replace core and rewind armature. If necessary to add band grooves grind into core. Check temperature on core with thermometer not to exceed 90°C.

(Continued)

carbon tetrachloride should be removed by applying a petroleum solvent. This will prevent corrosion later on.

Before any solvent is used, be sure that there is good ventilation and minimum fire risk. Do not let the workers' clothing become saturated with the solvent. Always have fire extinguishers of the carbon tetrachloride type handy. If a hose is used to spray either cleaning solution or varnish, make sure that the nozzle is grounded. Workmen using carbon tetrachloride should be guarded against breathing the fumes, and they should be under the close observation of someone familiar with artificial respiration. Where conditions are particularly bad, such as in pits, gas masks should be worn.

Special Treatment Required

The time to apply varnish treatment is after the motor has been thoroughly cleaned with a solvent. Use a baking varnish recommended by the supplier for the particular conditions encountered. Two dips and bakes may be sufficient in many industries, but splash-proof motors, as used for pumping oil wells, or enclosed motors, as used in corrosive atmospheres in refineries, should have four to six dips and bakes. One or two additional coats of red synthetic enamel may be justfied under extreme conditions.

Dry the motor in an oven before dipping in varnish. Electric or steam heat is the safest and most convenient. Make sure that suitable temperature control is provided and that it is effective so as to prevent injury to the insulation. Maximum dry out temperature is 115°C. Baking temperature for the varnish and length of the baking period will depend upon the type of varnish used.

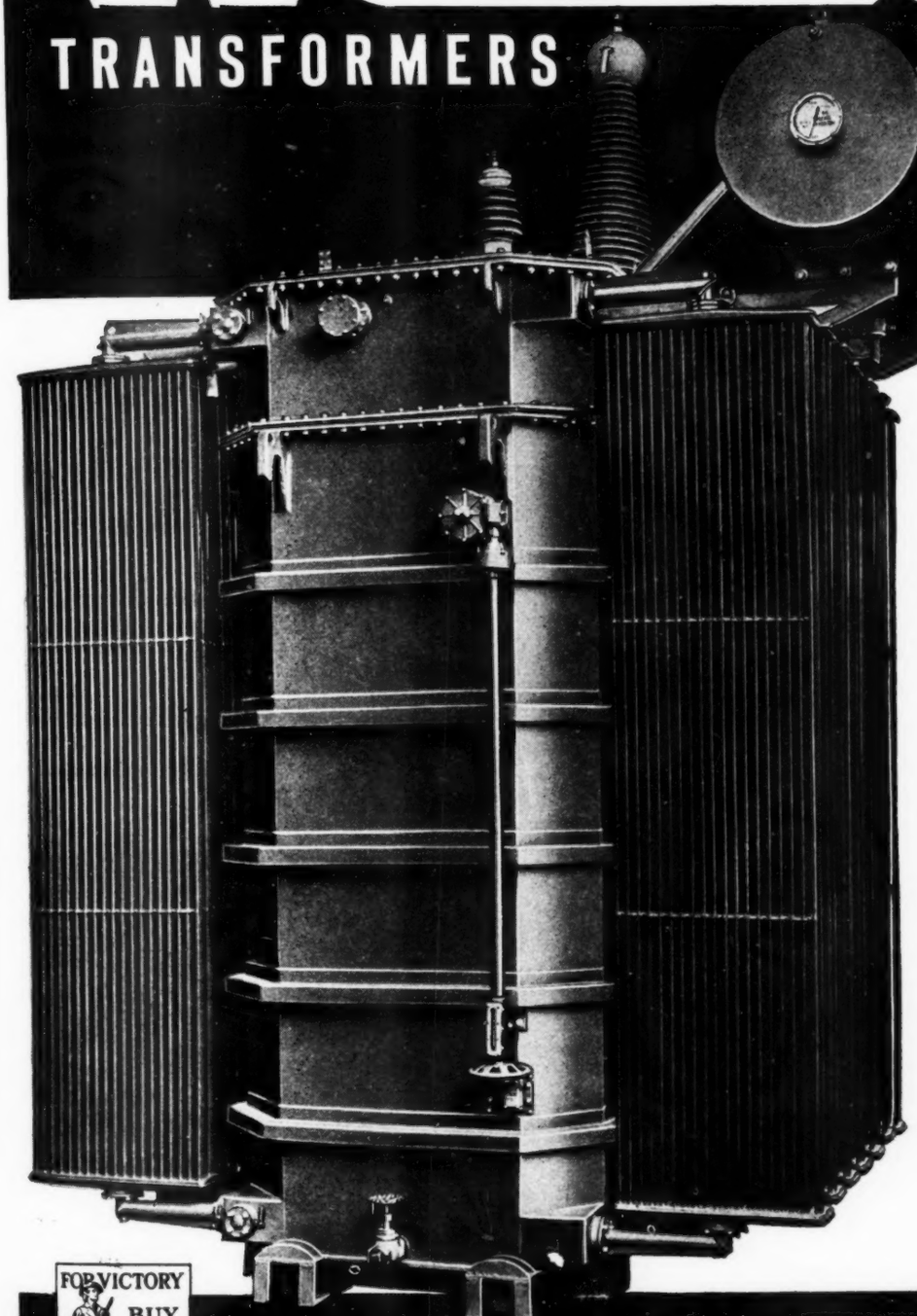
Insulation Testing

Insulation tests are made to determine the condition of the insulation. Although special conditions may justify dielectric tests over potential tests, high frequency tests, or dielectric power factor tests, a test to determine the insulation resistance is generally all that is required in maintenance work. Use Class B insulation for motors whose history shows breakdowns resulting from operation at elevated temperatures.

The most convenient way to read insulation resistance is with a Megger. The 500-volt type is generally used. A higher voltage Megger may damage low-voltage insulation. Remember that the readings are valuable only from a comparative standpoint and that they vary greatly with the temperature of the apparatus. A safe general rule is that the insulation resistance should be approximately one megohm for each

Wagner

TRANSFORMERS



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T43-3

Wagner Electric Corporation

ELECTRICAL AND AUTOMOTIVE PRODUCTS

TABLE 4 (Continued)

	(b) Hot commutator
Brush pressure too high.	Limit pressure to 2 to 2½ lb. per sq. in. Check brush density and limit to density recommended by the brush manufacturer.
Brushes off neutral.	Reset neutral.
Brush grade too abrasive.	Get recommendation from manufacturer.
Shorted bars.	Investigate commutator mica and undercutting and repair.
Hot core and coils that transmit heat to commutator.	Check temperature of commutator with thermometer to see that total temperature does not exceed ambient plus 55°C. rise, total not to exceed 105°C.
Inadequate ventilation.	Check as for hot motor.
	(c) Hot fields
Voltage too high.	Check with meter and thermometer and correct voltage to nameplate value.
Shorted turns or grounded turns.	Repair or replace with new coil.
Resistance of each coil not the same.	Check each individual coil for equal resistance to be 10 percent and if one coil is too low replace coil.
Inadequate ventilation.	Check as for hot motor.
Coil not large enough to radiate its loss wattage.	New coils should replace all coils if room is available in motor.
Overheating deteriorates insulation and shortens life of the motor.	
TROUBLE: *Motor vibrates and indicates unbalance*	
Armature out of balance.	Remove and statically balance or balance in dynamic balancing machine.
Misalignment.	Realign.
Loose or eccentric pulley.	Tighten pulley on shaft or correct eccentric pulley.
Belt or chain whip.	Adjust belt tension.
Mismating of gear and pinion.	Recut, realign, or replace parts.
Unbalance in coupling.	Rebalance coupling.
Bent shaft.	Replace or straighten shaft.
Foundation inadequate.	Stiffen mounting place members.
Motor loosely mounted.	Tighten holding down bolts.
Motor feet uneven.	Add shims under foot pads to mount each foot tight.
TROUBLE: *Motor sparks at brushes or does not commutate*	
Neutral setting not true neutral.	Check and set on factory setting or test for true neutral.
Commutator rough.	Grind and roll edge of each bar.
Commutator eccentric.	Turn and grind commutator.
Mica high not undercut.	Undercut mica.
Commutating pole strength too great causing over-compensation or strength too weak indicating under-compensation.	Check with manufacturer for correct change in air gap or new coils for the commutating coils.
Shorted commutating pole turns.	Repair coils or install new coils.
Shorted armature coils on commutator bars.	Repair armature by putting into first class condition.
Open circuited coils.	Same as above.
Poor soldered connections to commutator bars.	Resolder with proper alloy of tin solder.
High bar or loose bar in commutator at high speeds.	Inspect commutator nut or bolts and retighten and return and grind commutator face.
Brush grade wrong type. Brush pressure, too light. Current density excessive. Brushes stuck in holders. Brushes shunt loose.	See brushes.
Brushes chatter due to dirty film on commutator.	Resurface commutator face and check for change in brushes.
Vibration.	Eliminate cause of vibration by checking mounting and balance of rotor.
TROUBLE: *Brush wear excessive*	
Brushes too soft.	Blow dust from motor and replace brushes with a changed grade as recommended by manufacturer.
Commutator rough.	Grind commutator face.
Abrasive dust in ventilating air.	Reface brushes and correct condition by protecting motor.
Off neutral setting.	Recheck factory neutral or test for true neutral.
Bad commutation.	See corrections for commutation.
High, low or loose bar.	Retighten commutator motor bolts and resurface commutator.
Brush tension excessive.	Adjust spring pressure not to exceed 2 lb. per sq. in.
Electrical wear due to loss of film on commutator face.	Resurface brush faces and commutator face.
Threading and grooving.	Same as above.
Oil or grease from atmosphere or bearings.	Correct oil condition and surface brush faces and commutator.
Weak acid and moisture laden atmosphere.	Protect motor by changing ventilating air, or change to enclosed motor.
TROUBLE: *Motor noisy*	
Brush singing.	Check brush angle and commutator coating, resurface commutator.
Brush chatter.	Resurface commutator and brush face.
Motor loosely mounted.	Tighten foundation bolts.
Foundation hollow and acts as sounding board.	Coat underside with sound proofing material.
Strained frame.	Shim motor feet for equal mounting.
Armature punchings loose.	Replace core on armature.
Armature rubs pole faces.	Recenter by replacing bearings or relocating brackets or pedestals.
Magnetic hum.	Refer to manufacturer.
Belt slap or pounding.	Check condition of belt and change belt tension.
Excessive current load.	May not cause over-heating but check chart for connection shorted or ground and coils.
Mechanical vibration.	Check chart for causes of vibration.
Noisy bearings.	Check alignment, loading of bearings, lubrication and get recommendation of manufacturer.

1000 volts of operating voltage, with one megohm as a minimum.

Totally Enclosed Motors

Totally enclosed motors, totally enclosed fan-cooled motors, and totally enclosed explosion-resisting motors, all have a mechanical construction to prevent the admission of abrasive dirt and metallic particles that shorten the life of insulation. For these enclosed motors there are two points to observe: First, all exposed joints in the motor frame and brackets must be tight. Use a water-resistant grease in the bracket fits, if the motor is dismantled for any reason. Second, the motor must be provided with a drain plug or drain pipe at the bottom of the frame so that any accumulated water can be removed before causing trouble. This precaution cannot be used on explosion-proof motors.

Direct-Current Motor Repair

Direct-current motors add the commutator and its current-collecting details to the general maintenance problem. The armature is the heart of the d-c. motor. Through it flows the main line current, and if the machine is overloaded the armature is the first to give evidence of distress.

When dismantling a d-c. motor for periodic overhauling the following points should be observed. Do not roll the armature on the floor; a coil may be injured or the steel banding wire may be nicked. Support or lift the armature only by its shaft if possible. Never allow the weight of the armature to rest on the commutator or on the coils. Inspect the coils carefully to see that they are tight and when necessary replace the wedges. Replace any bands that may be loose.

So far as possible duplicate the banding originally supplied by the manufacturer. Do not change the material in the banding wire, the diameter of the banding wire, or the width or position of the band. Increasing the band width may cause heavy currents in the bands sufficient to over-heat and melt the solder.

Only experienced workmen should tighten loose commutators. If the commutator bars are tight they will give out a clear bell-like ring when tapped lightly with a small hammer. If the commutator does not ring, but gives out a flat sound when struck, the front Vee should be tightened.

The exposed portion of the front mica Vee ring is normally a catchall for oil and dirt. This section should be cleaned and protected with a layer of surgical tape and twine to prevent flashovers and breakdown to ground. Red synthetic enamel will give a smooth finish, resistant to oil and carbon dust.

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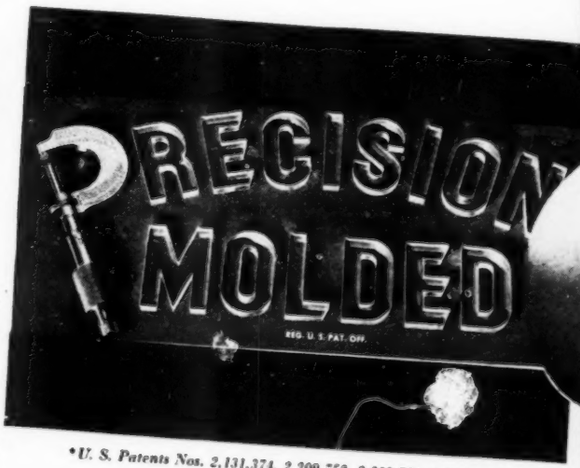
● ***Simpler and speedier to apply!*** Easier to lift, cut and score. Simpler to embed tie wires flush in surface, too!

● ***Precision pipe fit!*** Both pipe coverings and blocks of Plant Precision Molded 85% Magnesia are molded to exact final size and thickness... not molded oversize and then "milled" to size.

War has hastened by many years the introduction of this new, revolutionary, patented* ***Plant Precision Molded*** process of manufacturing 85% ***Magnesia*** heat insulating material. A chemically true 85% Magnesia, meeting the requirements of all Federal specifications, ***Plant Precision Molded*** incorporates advancements that deserve careful study wherever heat insulation is necessary. Complete descriptive material sent upon your request.



PLANT
RUBBER & ASBESTOS WORKS

Manufacturers of Plant Insulating Materials and Mechanical Packings Since 1920

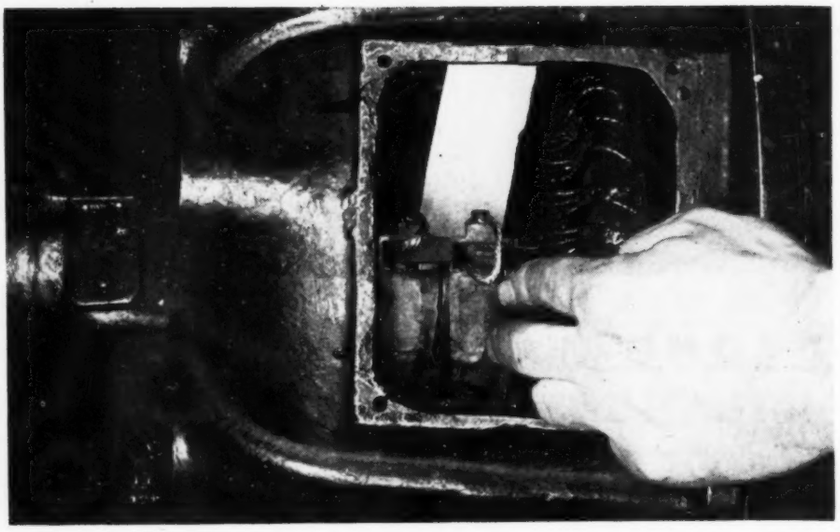
MAIN OFFICE: SAN FRANCISCO

Sales Offices in Los Angeles, Wilmington, and Oakland; distributors in principal cities.

Factories in Emeryville, San Francisco, and Redwood City, Calif.

*U. S. Patents Nos. 2,131,374, 2,209,752, 2,209,753, 2,209,754.

A thorough maintenance program does not neglect brushes



Check Brushes

Check the brush rigging carefully. Most brush holders in use today are box type, and the brush holder should be replaced when the inside broached section is worn.

The brushes themselves must fit properly, not so tightly as to stick, and not so loosely as to shift position when running. Make sure that the grade used is correct for the applications, using the advice of the manufacturer of the motor. Make sure that the fit of the brush on the commutator extends over the full face of the brush.

The spring tension on the brushes should be uniform so as to prevent selective action. The correct pressure will vary with the design of the machine and adjustments should follow the recommendation of the manufacturer. The brushes should be staggered in pairs of arms to prevent grooving of the commutator. Brush shunts should be kept tight and free from excessive corrosion so that current will be uniformly distributed to the brushes. Under bad conditions of corrosive atmosphere, the shunts can be protected by dipping in melted paraffin or in synthetic red enamel or by covering with woven cotton tubing.

Resurfacing of the commutator should be done in a lathe, or with a grinding rig. As it is impossible to obtain a true surface with a hand stone, it should be used only as an emergency. Practically all up-to-date d-c. machines have undercut mica in the commutators. This undercutting should be kept $\frac{1}{16}$-in. deep.

Gearmotor Lubrication

A gearmotor is a self-contained drive made up of a ball-bearing motor and a speed reducing gear unit. It is designed to take advantage of the electrical efficiency of accurately cut and properly designed gears.

Suggestions already given apply to the motor element of the gearmotor unit. Front and motor bearings are generally grease-lubricated and require the same attention as in standard ball-bearing motors. Rear bearings, gear box bearings, and the gears themselves are almost always splash-lubricated from the same oil supply reservoir in the lower section of the gear unit. Oil seals at each bearing prevent oil leakage into the motor windings and out along the driving shaft. The precision cut gears demand carefully selected lubricating oils. Use only top-grade oils of the viscosity called for by the manufacturer of the gearmotor. Give full particulars as to type of unit and operating conditions.

The areas of contact on gear teeth are relatively small and the pressures produced in transmitting the loads are relatively large. It is essential to provide a film of lubricant of sufficient strength to withstand the localized pressure during the period of contact. The peripheral speed of the gears governs the period of tooth contact and determines the time during which the film must withstand the pressures. When speeds are high, the time is very short, the loads are usually light, and a comparatively light-bodied lubricating oil can be used. When speeds are low and the loads heavy, the contact time is considerably longer and a heavier-bodied oil should be used.

See that the oil level marked for each gearmotor unit is maintained. For normal operating conditions, drain the oil reservoir in the lower section of the gear case once a year and refill with new oil.

Proper maintenance, as outlined in the foregoing, is important even in normal times. In these times when our war effort is demanding most of our critical materials, our manufacturing facilities and our manpower, the importance of an adequate maintenance program cannot be overstressed. Such a program will do much toward maintaining peak efficiency and making existing critical materials last for the duration.

—— ☆ ☆ ☆ ——

Periodic cleaning prevents dust and dirt from getting in the motor windings

NO. 6 OF A SERIES

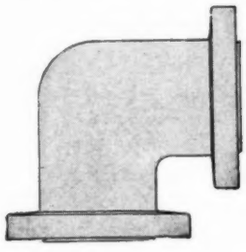
HOW TUBE-TURN WELDING FITTINGS BENEFIT WAR INDUSTRY

★ The ★ FIRST WELDING FITTINGS 1ST AND STILL THE BEST

Weight saved* with Tube-Turn Welding Fittings aids war industry—by economizing steel, speeding pipe erection, conserving supports, reducing shipping weight.

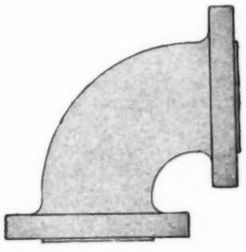
**Tube-Turn fittings in comparison below are 6", Schedule 80. Other fittings are 6", 600 lb. class.*

FORGED FLANGED ELBOW



450 lbs.

CAST STEEL FLANGED ELBOW

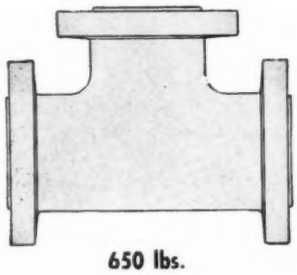


250 lbs.

TUBE-TURN WELDING ELBOW

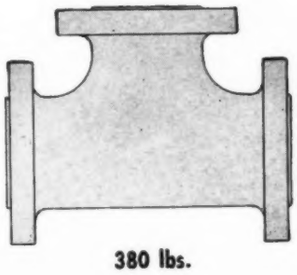
33½ lbs.

FORGED FLANGED TEE



650 lbs.

CAST STEEL FLANGED TEE



380 lbs.

TUBE-TURN WELDING TEE

80 lbs.

THE examples illustrated above demonstrate the tremendous differences in weight between Tube-Turn welding fittings and other types of steel fittings. These comparisons are for 6" size (see note above), and other sizes are more or less proportionate.

Weight saving *always* has been an important reason for specifying Tube-Turn welding fittings. But today's war production needs stress additional advantages of this feature. It saves steel—because less of this strategic metal is required in making Tube-Turn fittings. Piping systems welded with Tube-Turn fittings are *lighter* and *streamlined*—which speeds erection, saves space, and simplifies structural problems. Remember these timely points when you buy or specify fittings for oil, gas, power, chemical, heating, air, refrigeration and marine piping today!

TUBE-TURN

TRADE MARK

Welding Fittings and Flanges

TUBE TURNS (INC.) LOUISVILLE, KY. ● *Branch offices:* New York, Chicago, Philadelphia, Pittsburgh, Cleveland, Dayton, Washington, D. C., Houston, Los Angeles. ● *Distributors in principal cities.*

OTHER WAYS TUBE-TURN FITTINGS HELP WAR PRODUCTION:

SPEED INSTALLATION: Less time needed for aligning thanks to true circularity and uniform walls. Only simple butt welds required, easy even for novice welders. Whole section can be preassembled on the ground.

SAVES SPACE: Tube-Turn fittings permit streamlined, compact layouts and sharp angles—neater, more efficient piping.

REDUCES MAINTENANCE: No gaskets to replace, no nuts or bolts to tighten. Maintenance practically eliminated. Relieves men for other duties.

AVOID SHUT-DOWNS: Practically no danger of shut-downs due to connection failures as welding with Tube-Turn fittings *eliminates* the chances of leakage.

INCREASE SAFETY: Exclusive manufacturing process gives greatest possible strength in fittings, full freedom from leakage, and longer life in piping systems.

Winner of Army-Navy, Maritime Commission, Victory Fleet and Treasury Dept. flags.

P 509.12
P 952.1

Calculating Production Decline Curves For Natural Gas Wells

PART 2 (Concluded)

by Albert R. Greer

THE exact relation of cumulative production to time required, considering deviation: If the relation of P_R to Z for the pseudo-reduced pressure range concerned can be represented by a straight line, it is possible to determine the exact relation of cumulative production to time required for the special case in which n equals 1. As the pseudo-reduced pressure will be relatively short, a straight line can be drawn through the desired curve, T_R = constant, showing the deviation for any conditions up to P_R equals 2.0 (see Fig. 3), which corresponds to a pressure of about 1300 lb. per sq. in. This article is not concerned with pressures higher than that.

The exact relationship is: (n = 1.0)

$$\frac{(C_1-C^1)}{2}\left[\log_e(P_f^2-P_s^2)\right]-\left(\frac{D-D^1}{P_s}\right)\left(\tan h^{-1}\frac{P_s}{P_f}\right)-\left(\frac{A}{b}\right)\left(\frac{1}{(b)P_f+c}\right)+\left(\frac{B-A^1}{b}\right)\left[\log_e(bP_f+c)\right]=Ct.+\text{constant} \quad \text{equation (15)}\ddagger$$

Where:

P_c = critical pressure of the gas,
m = slope of the line T_R,
a = R (as used in Part 1).

$$b=\frac{m\,P_r}{Z_r\,P_c} \qquad c=\frac{(P_r)\,(K)}{Z_r}$$

K = intercept on Z axis (Fig. 3)

$$A^1=\frac{ab^2}{c^2-(P_s)^2(b^2)}$$

$$D^1=\frac{a+(A^1)\,(P_s)^2}{c}$$

$$C^1=\frac{a-(D^1)\,(bP_s+c)}{(b)\,(P_s)^2+cP_s}$$

$$A=(-c)\,(A^1)$$

$$B=-\frac{(a)\left(c^2+(b^2)\,(P_s^2)\right)}{(P_s^2)\left[b^2p_s^2-2c^2\right]+\frac{c^4}{b^2}}$$

$$C_1=-\frac{B}{b} \qquad D=\frac{2BcP_s^2}{c^2+b^2P_s^2}$$

The other coefficients have values as given previously.

‡Derivation given in appendix 2.

The relation of P_f to V is given in equation (18).

Relation of the Variables

The above equation requires considerable work to solve for the points with which to plot the cumulative production curve. Because of this the following approximate method is suggested for conditions in which the ratio of Z_r/Z_f is 0.9 or greater. The accuracy to be expected can be determined somewhat by an inspection of Fig. 4. Here, conditions are assumed so that Z_r/Z_f equals 0.785. Curve "A" shows the cumulative production curve without considering deviation. Curve "B" shows the exact cumulative production curve as given by equation (15), and curve "C" shows the resulting curve using the approximate method. As the ratio Z_r/Z_f approaches 1, curves "B" and "C" will draw nearer together and will approach curve "A." For ratios of Z_r/Z_f equals 0.9 or larger, curve "C" will coincide more closely to "B," and will probably be accurate enough to be consistent with other errors that cannot be exactly evaluated.

The "approximate method" is applicable for any value of n, and the curves may be calculated by either of the methods as outlined in Part 1, with the exception of two "corrections" that must be applied.

First: The total reserves, R, is given a new value (shown as R_x below). This is determined as follows:

Considering deviation from the gas laws calculate (from the true total reserves, R) the volume of gas that will be produced as the reservoir pressure drops from P_r to P_s. This amount will be greater due to "super-compressibility" of the gas than would be arrived at by direct proportion as in Part 1. In the equations derived in Part 1 it was assumed that the volume produced would be directly proportional to the drop in formation pressure, and as such, would be directly proportional to the total reserves, R. In order that this relation now exist, at least approximately, (that the actual total amount of gas produced will be directly proportional to the total reserves) the value R, is corrected to the value R_x so that it satisfies this condition (as an average).

The calculations are:

$$V_T=(R)\left(1-\frac{Z_rP_s}{Z_sP_r}\right) \quad \text{equation (16)}$$

Where:

Z_s = the deviation factor at P_s,
Z_r = the deviation factor at P_r, and
V_T = the total gas that will be produced as P_r drops to P_s.

$$R_x=(V_T)\left(\frac{P_r}{P_r-P_s}\right) \quad \text{equation (17)}$$

Second: The exact cumulative volumes for chosen values of P_f are calculated, either by direct determination of the deviation factor from the chart for each pressure and use of equation (14), or more readily, from the relation:

$$V=R\left(1-\frac{P_f}{bP_f=c}\right) \quad \text{equation (18)}$$

in which the coefficients have the values as given previously.

For values of Z_r/Z_f less than 0.9, or where greater accuracy is desired, the exact relation may be very nearly approached by calculating separate values of R_x for each value of V. This is true for the example given below, in which there is a large difference in the cumulative production curves (considering deviation in one and not in the other). It is assumed that this would also be true for conditions of lesser deviation and for other values of n.

Using this latter method, then, and equation (1) expanded to several terms, it is possible to determine a curve for any value of n, corrected for deviation, to almost any degree of accuracy desired. For most practical purposes, however, the shorter approximate methods will be sufficiently accurate.

Appendix 1

As used in this article the rate of flow of gas to the well bore is obtained by:

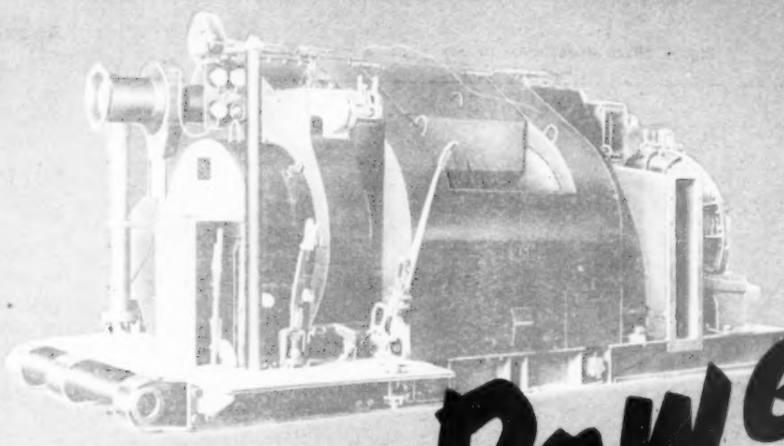
$$Q=C(P_f^2-P_s^2)^n \quad \text{equation (6)}\S$$

Where:

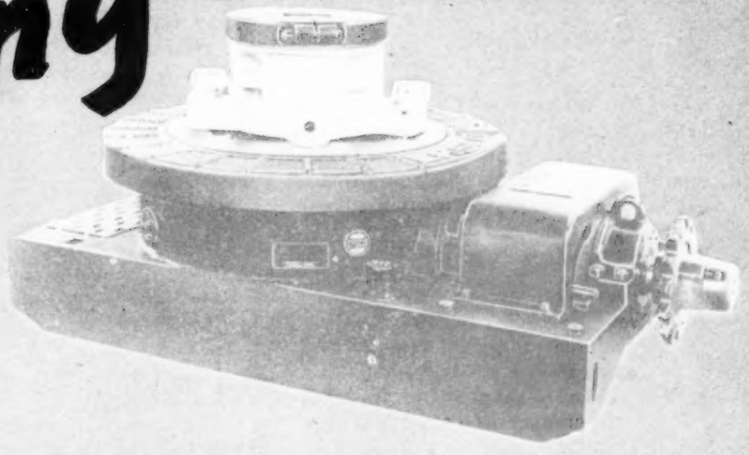
Q = rate of flow, cu. ft. per day,
P_s = pressure at the sand face, lb. per sq. in. abs.,
P_f = formation pressure, lb. per sq. in. abs., and
C, n = experimental constants.

The equation can be expressed as:

§Monograph 7, U. S. Bureau of Mines.



Drilling Power



. . . the built-in ability to buck the twisting, bouncing drag of the bit . . . to withstand the shock and strain of constant "round trips" . . . to handle and operate efficiently and speedily under all conditions . . . to stand up, tour after tour, under the continuous beating of tough going . . . that's *drilling power.*

Emsco oil field equipment is symbolic of this operating stamina that is so necessary to do the job effectively. *Drilling power* is built into every part, every bolt and nut of Emsco products. Top performance and recognized *staying* quality are prime guarantees of lasting satisfaction.

EMSCO *Oil Field Equipment*

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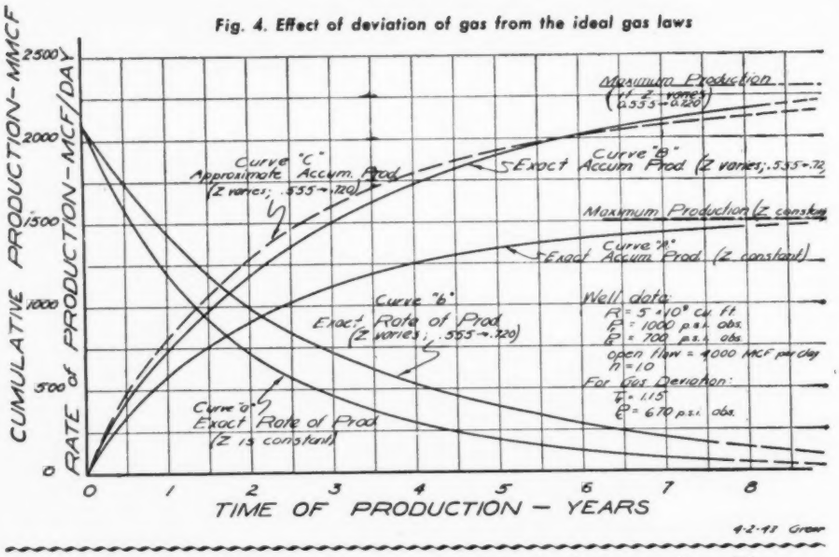
Fig. 4. Effect of deviation of gas from the ideal gas laws


CUMULATIVE PRODUCTION - MMCF
RATE of PRODUCTION - MCF/DAY
2500
2000
1500
1000
500
0
0 1 2 3 4 5 6 7 8
TIME OF PRODUCTION — YEARS
Maximum Production (Z varies; .555→.720)
Curve "C" Approximate Accum. Prod (Z varies; .555→.720)
Curve "B" Exact Accum Prod (Z varies; .555→.72
Maximum Production (Z constant)
Curve "A" Exact Accum Prod (Z constant)
Curve "b" Exact Rate of Prod (Z varies; .555→.720)
Well data:
R = 5 400 000 cu ft
P_i = 1000 p.s.i. abs
P_s = 700 p.s.i. abs
open flow = 4000 MCF per day
n = 1.0
For Gas Deviation:
T = 115
P = 670 p.s.i. abs
Curve "a" Exact Rate of Prod (Z is constant)
4-2-41 Greer

$$Q=\frac{dv}{dt}=C(P_f^2-P_s^2)^n \quad \ldots \text{equation (7)}$$

where V is the volume of gas (cu. ft.) produced during the time, t (days).

If the drop in formation pressure is directly proportional to the volume of gas withdrawn from the reservoir, the following relation exists:

$$\frac{V_f}{P_f}=\frac{V}{P_r-P_f} \quad \ldots \text{equation (8)}$$

Where:

V_f = volume of gas in reservoir at formation pressure, P_f, cu. ft.,

V = volume of gas produced causing the pressure drop from P_r to P_f, cu. ft.

Letting $V+V_f=R$, where R is the total reserves at formation pressure P_r,

then, $P_f=P_r\left(1-\frac{V}{R}\right)$. equation (2)

From which, $dv=-\frac{R}{P_r}dP_f$ . . . . . equation (9)

Substitute in (7) and rearrange terms:

$$\frac{R}{CP_r}\left(P_f^2-P_s^2\right)^{-n}dP_f=-dt \quad \ldots \text{equation (10)}$$

which can be expanded and integrated to give:

$$\left(\frac{R}{CP_r}\right)\left(\frac{1}{(2n-1)\left(P_r-\frac{P_rV}{R}\right)^{2n-1}}+\frac{nP_s^2}{(2n+1)\left(P_r-\frac{P_rV}{R}\right)^{2n+1}}+\frac{(n^2+n)(P_s^4)}{(4n+6)\left(P_r-\frac{P_rV}{R}\right)^{2n+3}}\right)=t+\text{const. (approximate)} \ldots \text{equation (1)}$$

by substituting for P_f, (equation 2).

The expansion was only carried to three terms in equation (1), and will not be accurate for most cases. Any desired accuracy can be obtained, however, by further expanding. The constant of integration is determined by substituting values of R, P_r, P_s, C, and n when t (and V) are equal to zero.

When $n=\frac{1}{2}$, the relation can be expressed as follows:

$$\frac{R}{P_rC}\int_{P_f=P_r}^{P_f=P_f}\frac{dP_f}{(P_f^2-P_s^2)^{1/2}}=-\int_{t=o}^{t=t}dt \quad \ldots \text{equation (11)}$$

which gives,

$$\frac{R}{P_rC}\left[\log_e\left(P_r+\sqrt{P_r^2-P_s^2}\right)-\log_e\left(P_f+\sqrt{P_f^2-P_s^2}\right)\right]=t \quad \ldots \text{equation (3)}$$

For n = 1:

$$\frac{R}{P_rC}\int_{P_f=P_r}^{P_f=P_f}\frac{dP_f}{P_f^2-P_s^2}=-\int_{t=o}^{t=t}dt \quad \ldots \text{equation (12)}$$

giving $\frac{R}{P_sP_rC}\left[\tanh^{-1}\frac{P_s}{P_f}-\tanh^{-1}\frac{P_s}{P_r}\right]=t$ . . . equation (4)

For $n=1\frac{1}{2}$

$$\frac{R}{P_rC}\int_{P_f=P_r}^{P_f=P_f}\frac{dP_f}{(P_f^2-P_s^2)^{3/2}}=-\int_{t=o}^{t=t}dt \quad \ldots \text{equation (13)}$$

giving $\frac{R}{P_s^2P_rC}\left(\frac{P_f}{\sqrt{P_f^2-P_s^2}}-\frac{P_r}{\sqrt{P_r^2-P_s^2}}\right)=t$ . . . equation (5)

Substitution of $P_r\left(1-\frac{V}{R}\right)$ for P_f will give equations in terms of V and t, which can be solved for various values and give points for the desired curves.

Appendix 2

Exact equation for the relation of V to t considering deviation from the ideal gas laws.

The volume of gas produced at any time is related to the formation pressure as: $V=R\left(1-\frac{Z_rP_f}{Z_fP_r}\right)$ equation (14)

The relation of the deviation factor to the formation pressure at any time (considering the reservoir temperature to remain constant) is given by the straight line equation:

$$Z_f=mP_R+K=m\frac{P_f}{P_c}+K \quad \ldots \text{equation (19)}$$

(see Fig. 3)

Substituting:

$$V=R\left(1-\frac{P_f}{\left(\frac{mP_r}{P_cZ_r}\right)P_f+\frac{P_rK}{Z_r}}\right) \quad \ldots \text{equation (20)}$$

or

$$V=a\left(1-\frac{x}{bx+c}\right) \quad \text{equation (21)}$$

Where: $b=\frac{mP_r}{P_cZ_r}$; $a=R$; $x=P_f$; $c=\frac{P_rK}{Z_r}$

Differentiating with respect to x:

$$dv=\frac{abxdx}{(bx+c)^2}-\frac{adx}{(bx+c)} \quad \ldots \text{equation (22)}$$

If n is 1, P_f is x, and P_s is s, the "back-pressure equation" becomes:

$$Q=\frac{dv}{dt}=C(x^2-s^2) \quad \ldots \text{equation (23)}$$

Substituting (22) in (23):

$$\frac{abxdx}{(x^2-s^2)(bx+c)^2}-\frac{adx}{(x^2-s^2)(bx+c)}=Cdt \quad \ldots \text{equation (24)}$$

which can be integrated to give:

$$\frac{(C_1-C^1)}{2}\left[\log_e(x^2-s^2)\right]-\left(\frac{D-D^1}{s}\right)\left(\tanh^{-1}\frac{s}{x}\right)-\left(\frac{A}{b}\right)\left(\frac{1}{bx+c}\right)+\left(\frac{B-A^1}{b}\right)\left[\log_e(bx+c)\right]=Ct+\text{const.} \quad \ldots \text{equation (25)}$$

Substitution of P_f for x and P_s for s gives equation (15). The value of the constants are as shown previously.

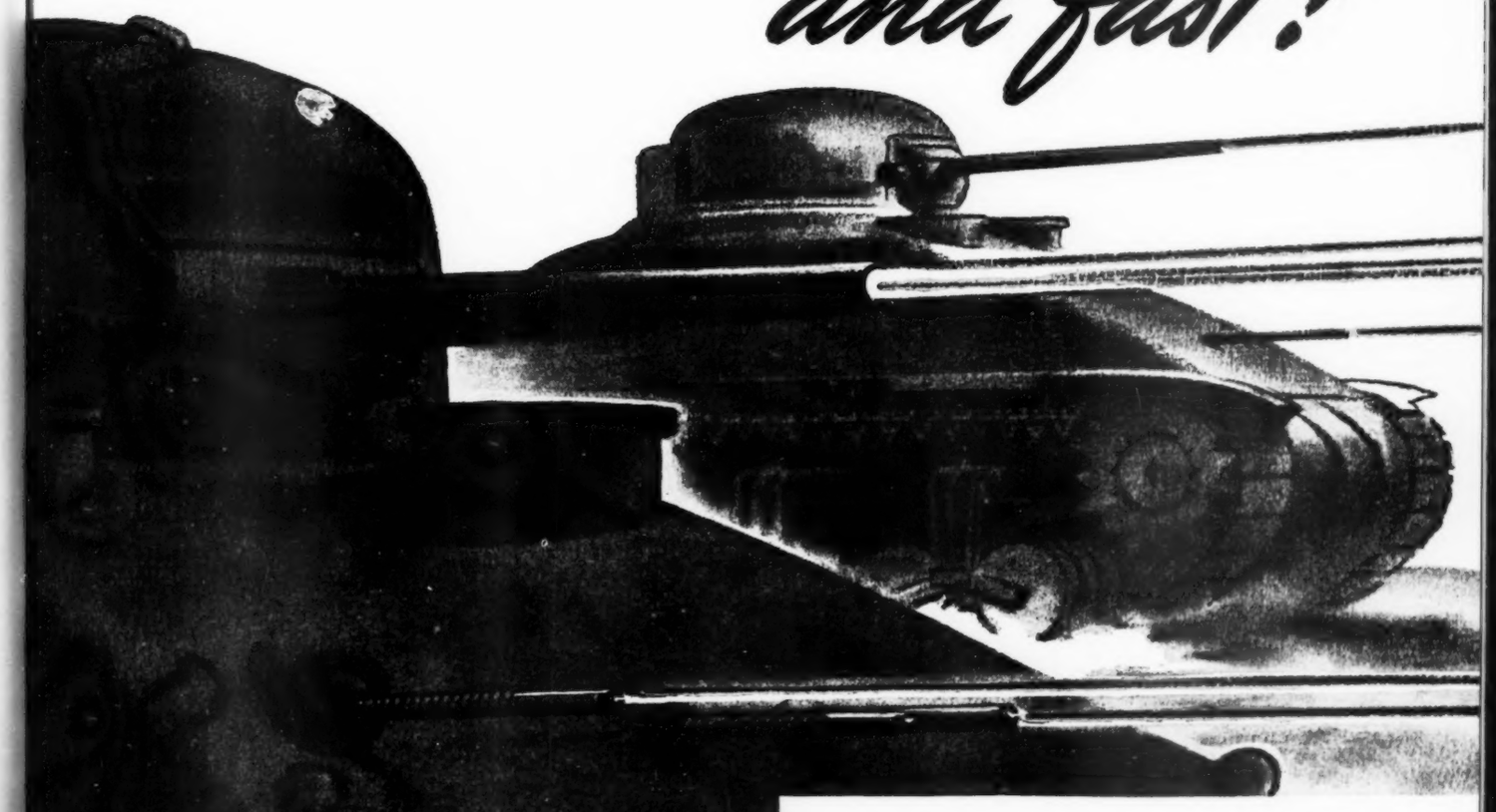
The constant of integration is determined by substituting values in the equation when t (and V) equal zero (and P_f equals P_r).

The volume at any time for a given value of P_f is:

$$V=R\left(1-\frac{P_f}{bP_f+c}\right) \quad \text{equation (18)}$$

☆ ☆ ☆

Effective *and fast!*



THE EFFECTIVENESS of one armored tank over another spells the difference between success and failure. The same is true of compounds designed to handle the demulsification problem in the oil industry.

Our armed forces are dependent on oil in many ways, and the products we give them must be the best.

If you are not sure that your cut oil is being treated to pipeline specifications with the greatest possible efficiency and economy, ask the Tretolite representative. He is a specialist, and cut oil problems are his specialty.

TRETOLITE COMPANY

Manufacturing Chemists

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Complete Service for Every Field

OIL IS AMMUNITION · TREAT IT RIGHT

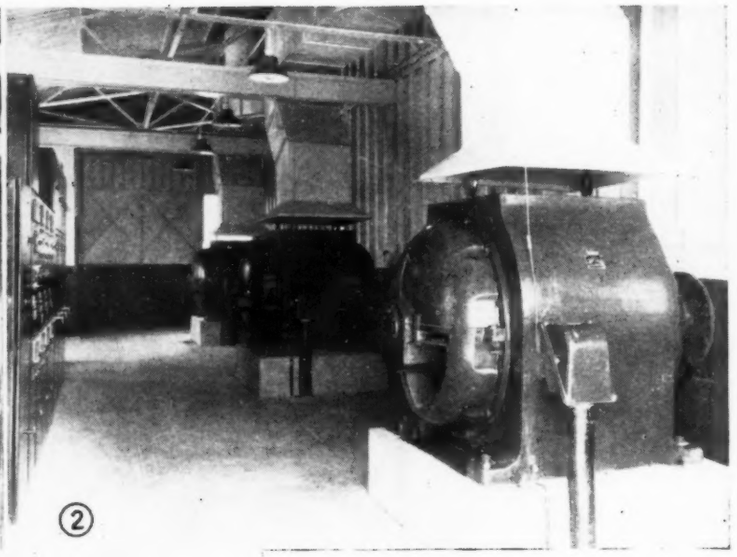
Tret-O-lite

REG. U. S. PAT. OFF.

DEHYDRATING **DESALTING**

War Emergency Pipeline Station

①



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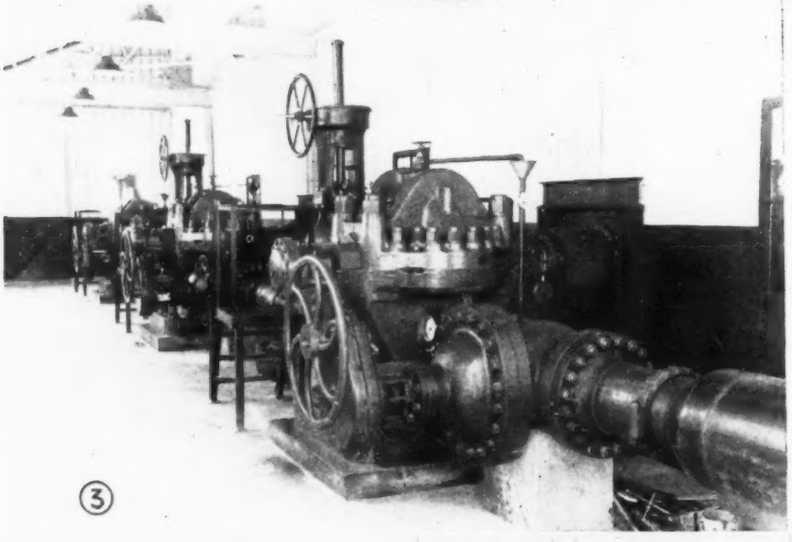

③

PUMPING stations on the War Emergency Pipeline's system, the "Big Inch" line, are of the same general type. The photographs on this page are of a typical station. (1.) Switchgear equipment for control of 2400-volt incoming line and reduced voltage starting of three 1500-hp. induction motors. (2.) The prime movers are 1500-hp. motors designed for a synchronous speed of 1800 r.p.m. and have a full load speed of 1785 r.p.m. (3.) Each of the main centrifugal pumps has a rating of 8750 gal. per min. operating against a total head of about 660 ft. (4.) Exterior view showing several of the buildings. (5.) Transfer pumping units.

④

⑤

WHERE *Service* COUNTS

HYDRAULICS Rodgers KEEP THE WORLD MOVING

To service hundreds of miles of war emergency pipelines, Rodgers Portable Hydraulic Straightener for pipe and kellys is an indispensable tool for any field operator. The unit is very convenient to handle, making it entirely practical to do the work in the derrick or on the ground, since the total weight of cylinder and frame is slightly over 400 lbs. The Rodgers Portable Hydraulic Straightener can be easily dismantled, making it possible for one man to do the job with speed and accuracy. ★ ***If it's a Rodgers, it's the best in Hydraulics . . .*** Rodgers Hydraulic Inc., St. Louis Park, Minneapolis, Minn.

Manufacturers of:

UNIVERSAL HYDRAULIC PRESSES
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HYDROSTATIC TEST UNITS
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Thiokol—Rapidly Developed Commercial Synthetic Rubber

Exclusive

☆ Wartime demand and natural rubber shortage has resulted in finding numerous new applications requiring special properties of Thiokol poly-rubber

by J. W. Crosby

Sales Manager, Thiokol Corporation

IN 1929 a small New Jersey corporation gave America its first commercial synthetic rubber. Known as Thiokol, this laboratory product was made by mixing sodium polysulphide and ethylene dichloride and adding a mild acid to coagulate the resultant milky latex. During the next few years several new Thiokol rubbers, based on variations and modifications of the original polysulphide reaction, were placed in production; and long before the Japanese conquests in the Far East brought on the present rubber crisis, these synthetics were being supplied in ever-increasing quantities for special industrial purposes where their resistance to oil, gasoline, and oxidation, impermeability to gases, and other properties made them outperform natural plantation rubber.

Among the prewar applications of Thiokol synthetic rubbers were aircraft, automotive, and Diesel fuel lines; large-diameter hose for the petroleum industry — including refineries, marine fueling depots, and service stations; electrical insulation; press blankets, rollers, and plates for the printing trades; paint spray hose, and even small oil-proof washers for dial telephones. In molding powder form the synthetics were used for a wide range of molded goods, and in solution form for coating and impregnating fabrics and paper. More than 24 different parts in the 1942 Chrysler cars utilized Thiokol synthetics.

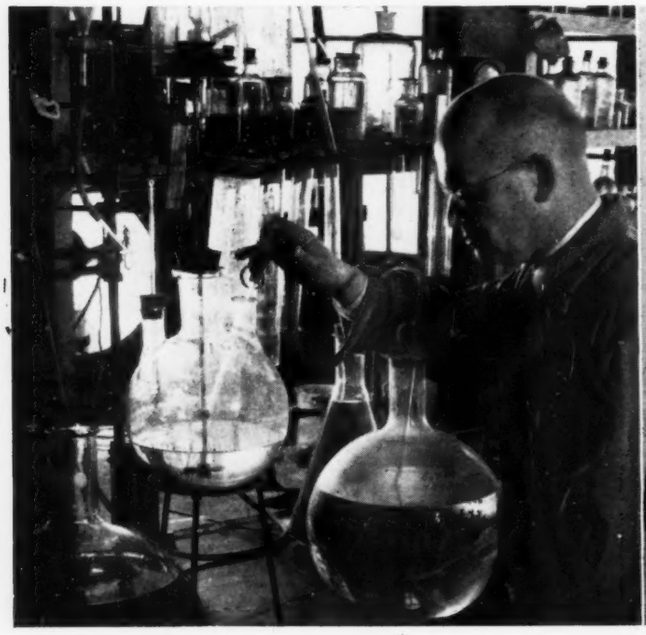
THE AUTHOR

J. W. Crosby was born and educated in Toronto, Canada, and attended Technical School and the University of Toronto—Spent four years in the army and thereafter went to work for Gutta Percha and Rubber, Ltd., serving in various technical and production capacities—In 1936, when in charge of the development of mechanical rubber goods, he resigned to accept the position of special field representative for Thiokol Corporation, Trenton, New Jersey—In 1940 was made sales manager.

War Emergency Development

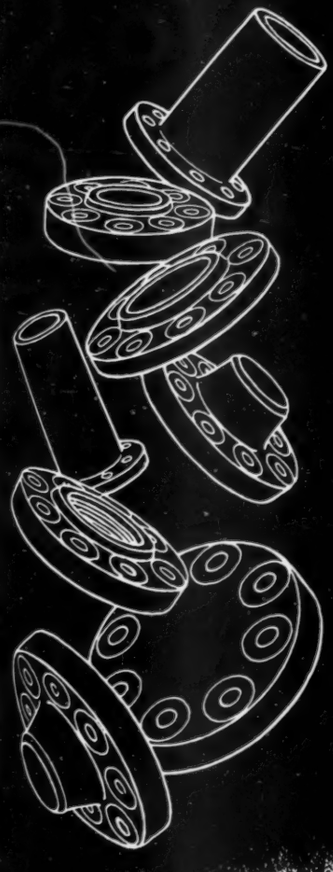
The tremendous demand of wartime production coupled with the shortage of natural rubber resulted in the discovery of new applications requiring the special properties of Thiokol poly-rubber. These included Mareng cell airplane gas tanks and fuel bladders for emergency gasoline storage and for converting box cars to oil carriers; self-sealing gasoline tanks and fuel lines; impregnated cotton grain bags for transporting fuel in the field, and coating and linings for underground, prestressed cement gasoline storage reservoirs. In the form of a powder that was insoluble in any known solvent, it was applied to battleship and merchant vessel propeller-shafts and external shaft supports, and submarine submersion tanks with a special fusing spray gun to form a coating that was equally resistant to the abrasive action of a desert sandstorm and the pounding and corrosive effects of salt water. As a coating on felt it provided a better-than-the-

Dr. J. C. Patrick, vice-president of Thiokol Corporation and discoverer of first Thiokol synthetic rubber in 1921 in his Trenton, New Jersey, laboratory



The tire shown here was given two coats of Thiokol latex and then run 700 miles without wearing down to original carcass

July 15th



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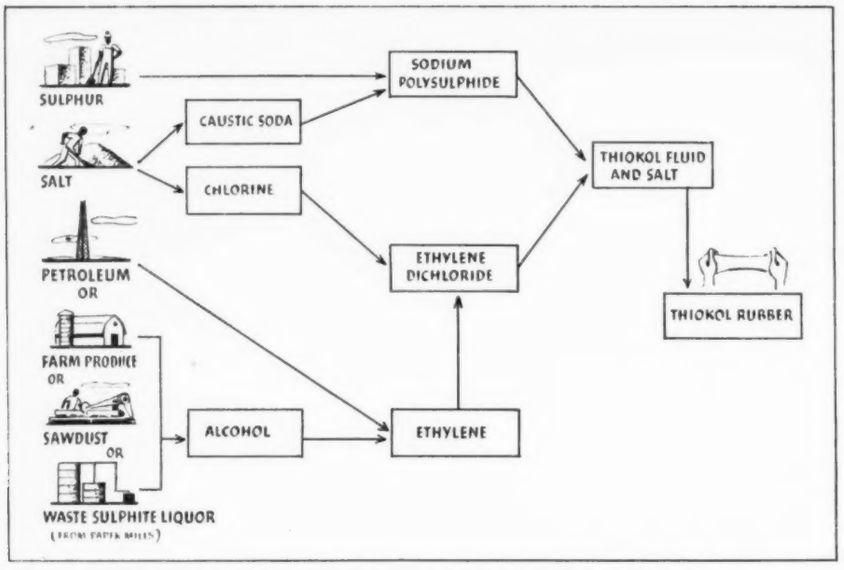
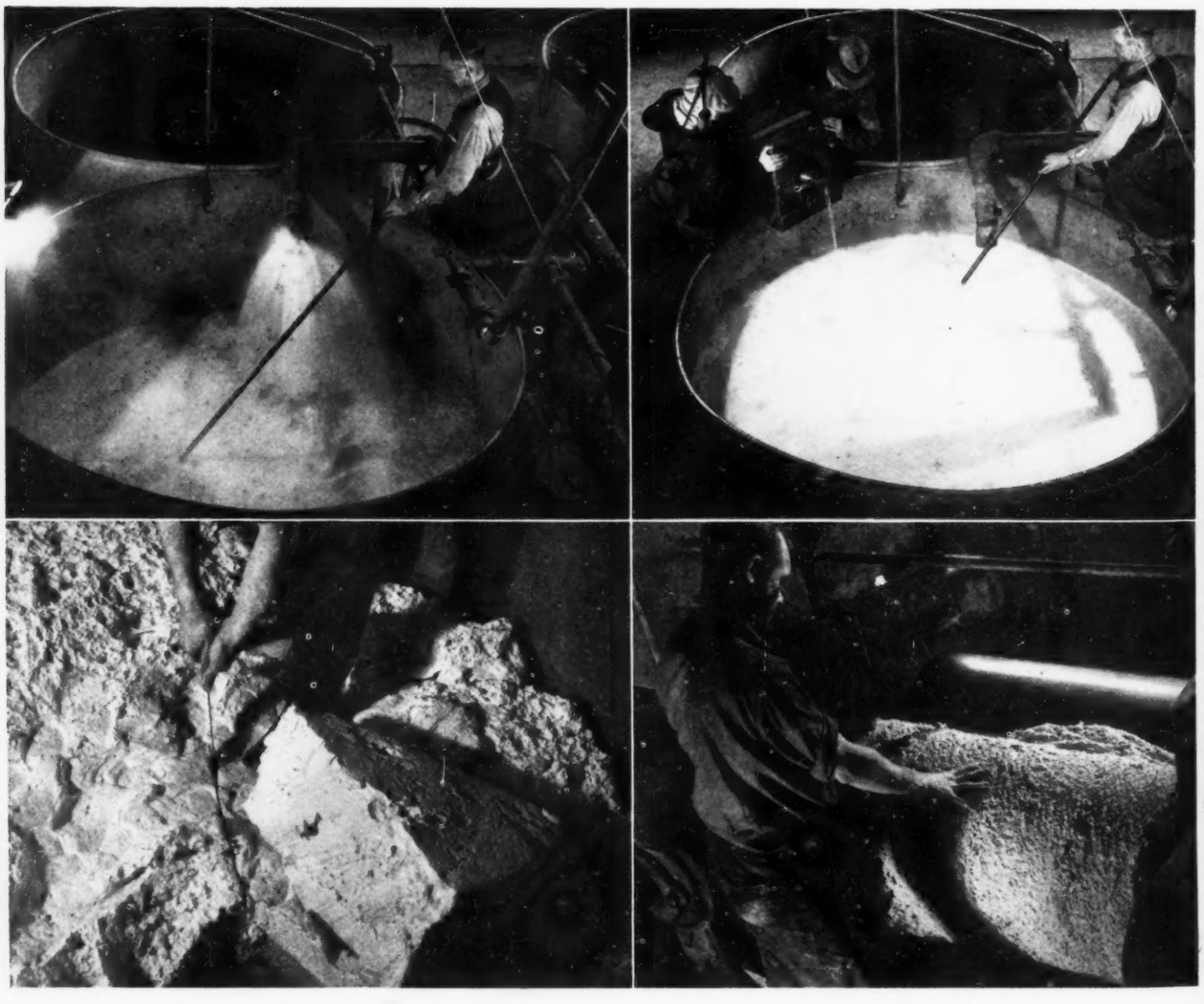


Chart showing materials and steps in making Thiokol

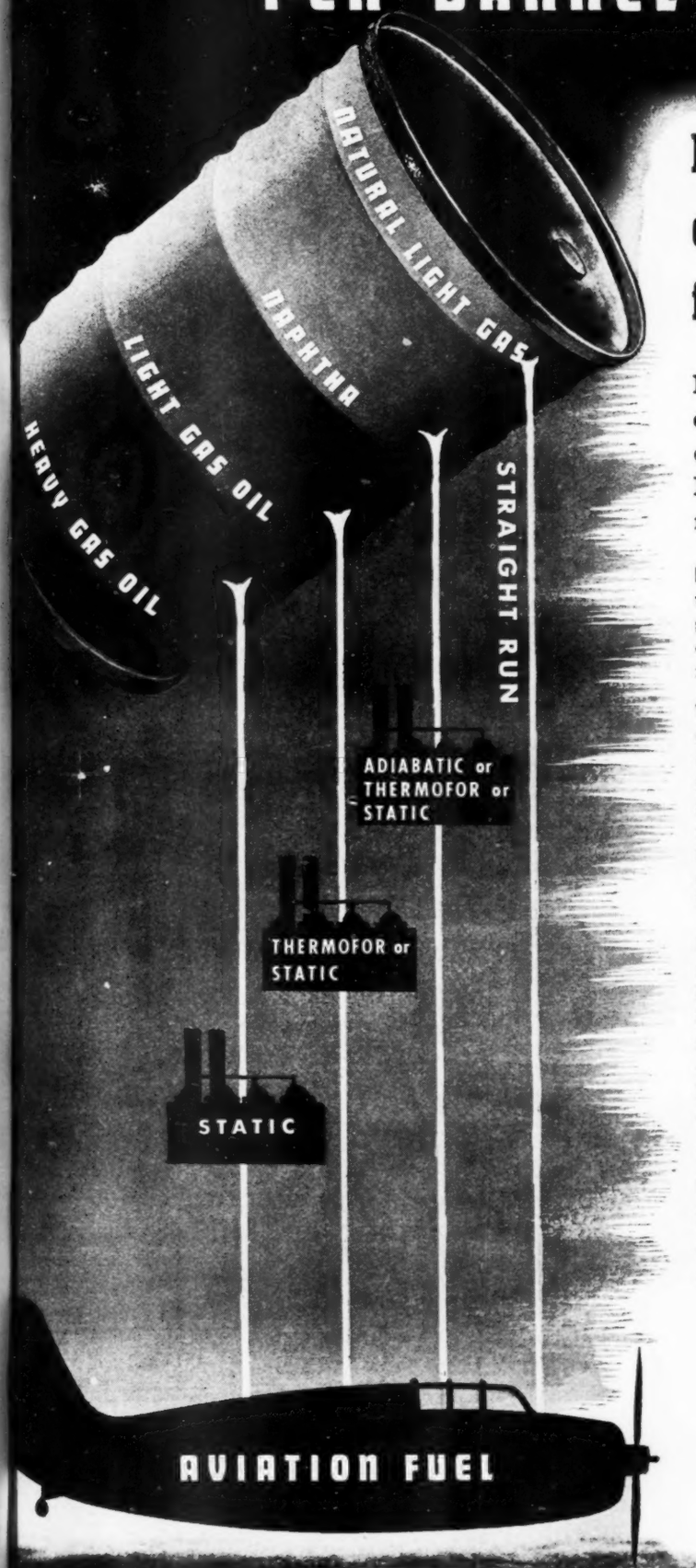
original replacement for sponge rubber cushioning and gaskets on army trucks and jeeps.

The second big war-development was the investigation of Thiokol synthetic rubbers as a substitute for natural rubber in the tire field where it was recommended largely because it could be rapidly produced from non-critical materials (salt, sulphur, and petroleum or alcohol). Production facilities could also be easily expanded through the conversion of tetra-ethyl lead or other chemical plants or by new construction in which little or no steel was required for either plant or equipment. In cooperation with the Tire Committee of the Automotive and Rubber Industries, Thiokol chemists formulated a material known as Thiokol N that proved adaptable for recapping, and which gave from 8,000 to 10,000 miles of service at speeds up to 40 miles per hour in a series of exhaustive road tests. This

Top left—First step in making Thiokol synthetic rubber is to add sodium polysulphide to ethylene dichloride to form viscous, milky fluid. Top right—Acid is used to coagulate milky fluid or latex. Excess liquid is drained off. Lower left —Solid crude rubber remaining in vat is cut into chunks. Lower right—Presses squeeze out remaining liquid. Rubber is then cut into sheets for processing like crude rubber



MAKE MORE CATALYTIC AVIATION GAS PER BARREL OF CRUDE



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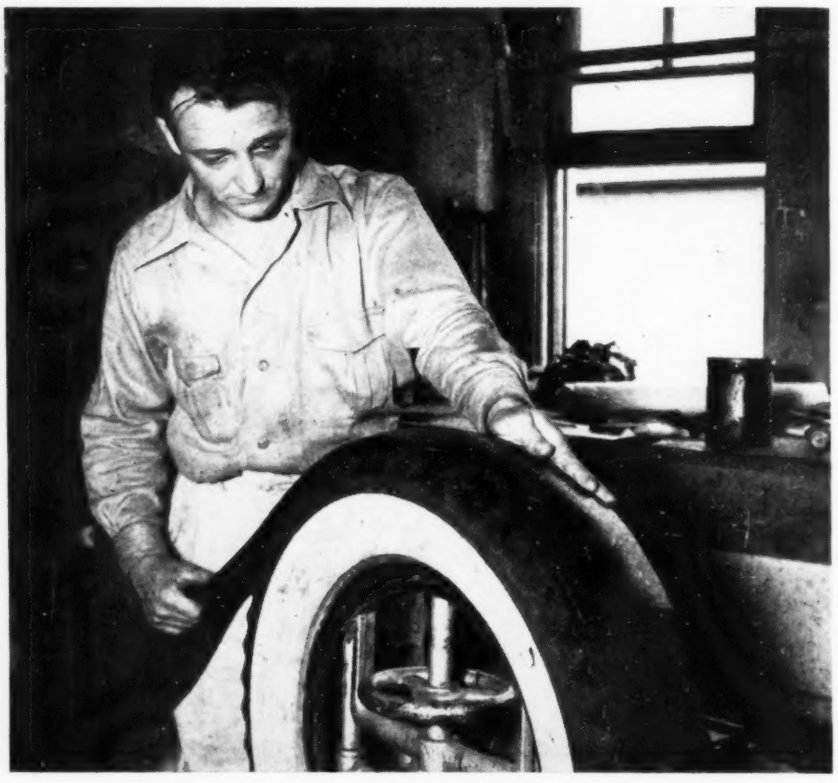
material was later cited by the Baruch Report as "the most rapidly produced synthetic material suitable for retreading civilian tires" with the recommendation that 60,000 long tons of the tire rubber alone be produced during 1943.

Manufacture of Thiokol

Today in addition to the Thiokol Corporation factories in Trenton, New Jersey, plants in New Jersey and Michigan are turning out Thiokol synthetic rubbers for industrial, military, and tire uses. A giant new producing unit is also under construction in Texas. Regardless of the type of Thiokol being produced, the procedure is basically the same. Sodium polysulphide, made from sulphur and salt, is mixed in huge cast-iron, wooden, or cement vats with ethylene dichloride, manufactured from natural gas or other petroleum derivatives. Mild hydrochloric acid is then added to precipitate the crude Thiokol. The liquid, a salt solution, is then drained off, and the solid material in pellet form is dried by being run through a press to remove the remaining liquid and compress it into sheets. In this form the Thiokol crude is shipped to regular rubber plants where it is handled in much the same way as natural crude rubber.

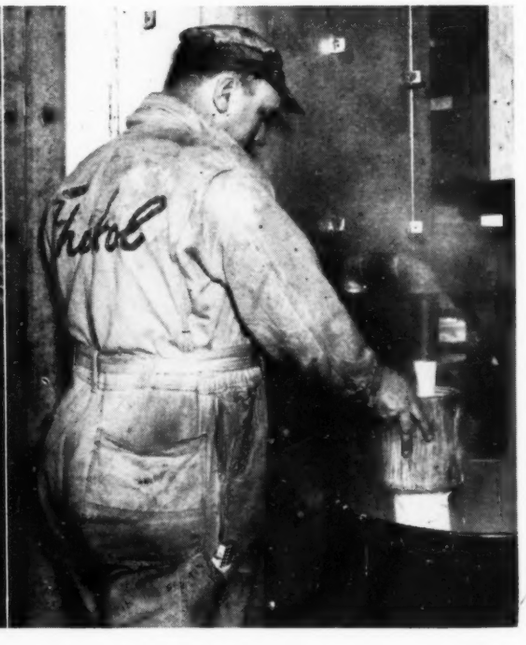
The one exception to this basic procedure is the new Thiokol latex, which is not coagulated but drawn from the mechanical rubber trees in liquid form. The entire present output of this latex is now going into the production of airplane gas tank bladders, and the coating of cement fuel storage reservoirs where actual contact with the cement has been found to lower the octane rating of high test aviation fuels.

In conclusion, it is interesting to note that although little or no steel is required in the production of Thiokol, Thiokol synthetic rubber is used in the production of steel. A special Thiokol used as a bonding material for the brick lining and known as Vitrobond has proved superior to other materials for lining the all important pickling tanks in steel production.



Retreader applying Thiokol synthetic rubber camelback to tire carcass.

Self-sealing gas tanks such as one being installed below have an inner layer of Thiokol latex



A workman taps a mechanical rubber tree in Thiokol plant

Role of Clad-Steel Plate In Petroleum Industry War Effort

PETROLEUM ENGINEER Exclusive Feature

☆ Clad-steel has wide use in petroleum and refinery operations and aids in conservation of rare metals of which there are critical shortages due to war demands

by Martin J. Conway
Special Engineer, Lukens Steel Company

EARLY in 1931, the announcement was made for the first time of a new composite metal or bi-metal called "nickel-clad-steel." Nickel-clad-steel plates are usually made of mild steel and malleable nickel. Most frequently the steel constitutes 90 percent of the thickness and nickel 10 percent, although the thickness of the nickel surface may range from 5 percent on exceptionally heavy plates to 40 percent on plates used for such applications as shells where the inside surface is machined after the shell is rolled up and welded.

Both steel and nickel have like properties, at rolling temperatures as well as at room temperature. Iron and nickel are in complete solid solution at temperatures of about 2300°F. to 2400°F. Thus the process of manufacture employed by the company with which the writer is affiliated effects an excellent bond between the two metals. The zone of fusion between the nickel and the steel can be distinctly detected and indicates that the nickel and steel have formed an iron-nickel alloy at the interface.

The nature of the bond between the nickel and steel is still somewhat of a mystery. Sectioned specimens when polished always show a clear line of demarcation between nickel and steel, inconel and steel, or monel and steel. It can be safely stated, however, that having once obtained a good bond, no case has ever been known of clad-steel plates separating, no matter how severe subsequent drawing and forming operations may have been.

Tensile Strengths

Actually, the tensile strength of the bond between nickel and steel has been shown by test to be greater than 55,000 lb. per sq. in. Fig. 1 illustrates how a special machined bar welded from two cones, one of nickel and one of steel, used to hold the nickel-clad plate specimen, when tested in a tensile testing machine fractured in the steel weld metal, not at the bond between nickel and steel.

MARTIN J. CONWAY

mechanical and chemical engineer and special engineer for the Lukens Steel Company, has been identified with steel mills, iron works, and fuels and combustion engineering for the greater part of his career — For a number of years he was fuel engineer for the Pittsburgh Crucible Steel Company, Midland, Pennsylvania, fuel engineer for the Wheeling Steel Corporation, Steubenville, Ohio, in charge of gas producers, boiler plants, metallurgical furnaces, and coal mines—During recent years he has been connected with the Lukens Steel Company of Coatesville, Pennsylvania, as special engineer in the petroleum industry—He is a member of the A.P.I., A.S.M.E., Association of Iron and Steel Engineers, Iron and Steel Institute, New York and London, and other societies.

Another useful characteristic of clad metals is that the tensile strength of composite clad plate is somewhat greater than that of a steel plate of the same overall thickness. In tests using identical grades of clad- and unclad-steel, with the clad specimen having 10 percent nickel on one surface, the yield point for the steel alone averaged 42,200 lb. per sq. in. and for the bi-metal plate 45,600 lb. per sq. in.

The steel of the composite plate is selected so that the ultimate strength of the clad plate will show a minimum strength of 55,000 lb. per sq. in., thereby meeting the requirements of A. S. M. E., S-1, flange quality specifications. This is actually a conservative figure, as tests on "as rolled" nickel-clad steel plate specimens of gauges varying from $\frac{3}{16}$ in. to $\frac{3}{8}$ in. showed an average ultimate tensile strength of about 63,500 lb. per sq. in. Other physical characteristics included an average of 27.5 percent elongation in 8 in., and percent reduction of area ranging from 53.2 to 61.7 percent.

In general, we may say that nickel-clad-steel plate, like inconel-clad-steel plate, and monel-clad-steel plate, is steel protected on one side or both sides with a dense, homogeneous layer of corrosion-resisting metal. With nickel-clad-steel, for instance the nickel surface possesses the same chemical and physical properties as hot-rolled or hot-forged nickel in other forms. It is firmly and permanently bonded to the steel base plate and does not separate from it as a result of temperature change, pressure, vacuum, or deformation in forming. See Table 1.

Features of Clad-steels

The availability of large and thick clad-steel plates makes possible the construction of large pressure vessels, evaporators, storage tanks, railroad tank cars, and many other types of equipment with a pure nickel, inconel, or monel inner surface, free from the many disadvantages of thin, loose linings, having the tendency to collapse when operated under vacuum.

The bond between the two metals gives the clad-steel plates heat conductivity equal to that of solid steel plate, and maximum thermal efficiency is obtained in all equipment requiring heat transfer through the wall. The thermal coefficients of expansion of nickel and steel, for instance, are nearly identical. Temperature changes within the range where nickel and steel may be used will, therefore, not affect the bond.

The nature of this bond between the component metals of the plate enables the fabricator to employ the methods usually followed in fabricating equipment from solid steel plates. Such cold-working operations as shearing, punching, bending, flanging, and forming are done in the customary manner, whereas hot-working includes spinning, flanging, and die-pressing. In pressing and flanging, the nickel may be formed on either the inside or outside of the formed part. Another feature of importance to the engineer is the excellent thermal conductivity of the plate. There is no break at the junction of the two component metals, there is no interruption to the flow of heat by surface transference. This fact makes the use of nickel-clad plate practicable in equipment where heat transfer is of importance.

Experience has demonstrated, however, that there are a few precautions that must be taken in its fabrication into equipment. The application usually makes it imperative that only a continuous non-ferrous surface be exposed to the corroding medium. Otherwise an iron-nickel couple will be set up and rapid deterioration will occur, depending of course on the corrosive medium. In riveting, solid corrosion-resisting metal rivets or rivets protected by nickel, inconel, or monel should be employed. Welding is performed with nickel, inconel, or monel rods of the covered electrode type. In hot-working, the serious nature of the effect of sulphur on nickel should be remembered. If the sulphur content of the gases is high, the nickel is attacked along the grain boundaries and loses its ductility. This action of sulphur was one of the difficulties that had to be overcome in the manufacture of large size plates. Low sulphur content fuels should always be used in heating to prevent damage to the material.

In the company's plant, natural gas is used for heating, melting, and heat-treating operations, and hence the operators are able to avoid harmful sulphurous attack. In addition, natural gas in this instance proves to be the most economical fuel. In other areas, however, kerosine, gasoline, charcoal, "blacksmith" coal, and coke from treated coal have been used successfully for heating and heat-treating clad-steels during fabricating process.

TABLE I

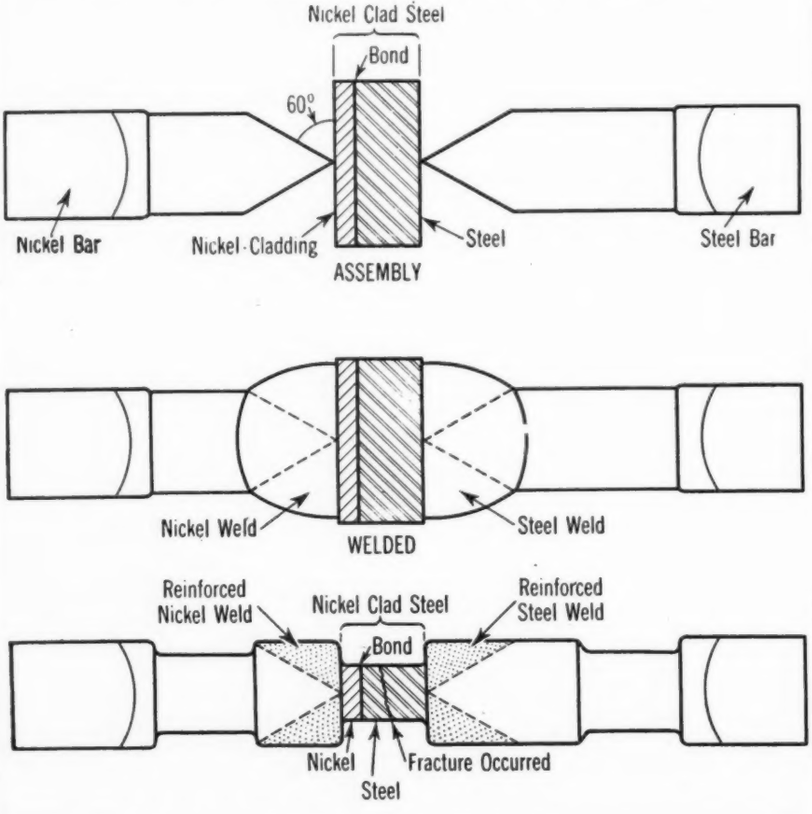
Nominal compositions, percent

	Nickel	Copper	Chromium	Iron	Manganese	Silicon	Carbon
Nickel	99.4	0.1	....	0.15	0.2	0.05	0.1
Inconel	79.5	0.2	13.0	6.5	0.25	0.25	0.08
Monel	67.0	30.0	....	1.4	1.0	0.1	0.15

Mechanical properties (hot-rolled plate)

Metal	Yield point, 1000 lb. per sq. in.	Tensile strength, 1000 lb. per sq. in.	Elongation, percent in 2-in.	Brinell hardness
Nickel	20-75	70-100	45-30	100-200
Monel	40-90	80-110	45-20	140-220
Inconel	45-95	100-140	40-20	160-240

Fig. 1. Machined test specimen, standard 0.505-in. diameter



Cold Working

Cold operations such as bending, flanging, forming, shearing, beveling, and the like, are performed exactly as in common steel plate work. No change in equipment or provision for special tools is required. Whenever possible, nickel-clad-steel plates should be handled around the shop and to the shears and punches with the nickel side up to prevent gouging and deep scratching of the cladding. Shearing and punching are best done to throw the burr on the steel side.

Severe cold operations, such as pressing heads and die work, generally require annealed plate.

Heating for Hot Working

Nickel-clad-steel should be heated in furnaces designed so that the metal is heated outside the actual zone of combustion. A reducing atmosphere should be maintained by adjusting the fuel-air mixture to give an excess of carbon monoxide and avoid excessive oxidation. The stack dampers should be adjusted to maintain a positive pressure within the furnace to prevent an intake of air under the door and through other openings.

The plate should be supported on clean steel rails or clean fire brick. This is to keep the nickel from contact with slag and cinder, on the furnace bottom, that might be the cause of damage through embrittlement.

Whenever possible, the plates should be heated with the nickel side up. Damage to the nickel may often be prevented when combustion and fuel conditions are not entirely suitable, by covering the nickel surface with a lime wash, or asbestos sheeting.

Surface Cleaning

During transportation and handling in the fabricator's shop, small particles of iron, often in the form of dust and

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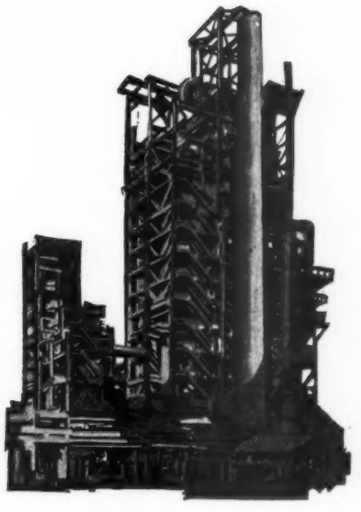

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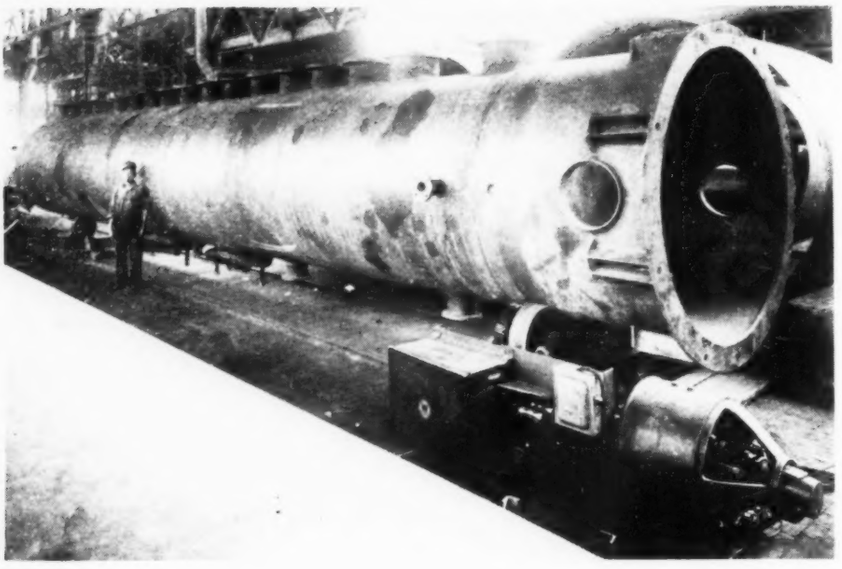

The upper 15 ft. 6 in. of this 43-ft. 6-in. high by 6-ft. diameter distillation tower was fabricated of 20 percent monel-clad-steel 23/32 in. thick

mixed with grease, collect on the nickel surface. A clean appearance can be restored by removing any grease with an organic solvent such as carbon tetrachloride, trichlorethylene, or a hot caustic cleaning solution. Then, the nickel surface should be washed and scrubbed with a solution of commercial hydrochloric (muriatic) acid, in the proportion of 1 gal. of water to ½ to 1 gal. of 23° Bé. acid. This should be followed by a rinse of plain water, which, when wiped dry, will leave the surface of the nickel satisfactorily clean.

In order to avoid contamination of the nickel surface with shop dirt, a protective paper coating may be applied to the nickel surface of nickel-clad-steel plate. This paper coating may be left in place until fabrication has been completed.

During these emergency times, rare metals have to be strictly rationed, owing to their demand for war purpose. Whenever it is possible to substitute clad plate for solid rare metal, it helps to conserve available supplies of rare metal, in addition to contributing suitable material for various important processes requiring these corrosion-resisting materials that otherwise could not be handled by the use of steel plate.

Wide Application of Clad-steel

Among the many uses for clad plates are: in distillation towers, heat exchangers, agitators, storage tanks, digestors, as well as for other services in the petroleum industry, and in the synthetic rubber, explosive, and chemical industries.

The following reasons enter into consideration of the use of corrosion-resisting clad-steel plate for process equipment:

1. To prolong life of the equipment due to the ability of the material selected to resist corrosion under the conditions of use.

2. To protect the quality of the products manufactured or processed in the equipment. This advantage would include the prevention of harmful contamination or discoloration of the products with metallic salts. In some cases, contamination products may act catalytically.

3. Sanitary reasons. Under this heading, would come ease of cleaning, ease of sterilization to prevent bacterial growth and prevention of adherence of products, as may be the case with a surface that has been roughened by corrosion. Also in connection with adherence of products to the surface, would be better heat transfer, if such is a problem.

4. Reduction of maintenance cost on equipment involves not only the actual cost of replacement materials and necessary labor, but also lost time and lost production with plant processing equipment. The cheapest equipment is, in many cases, by far the most expensive equipment when these costs are taken into consideration.

5. Reduction in cost of equipment made possible by reduction in thickness of material used. In many cases with materials that are not particularly resistant to corrosion, it is necessary when designing equipment to use extra thick material to allow for corrosion attack during the intended life of the equipment. Also consideration must be given to the higher physical properties in some corrosion-resistant materials, which may permit the use of thinner material to obtain the same strength.

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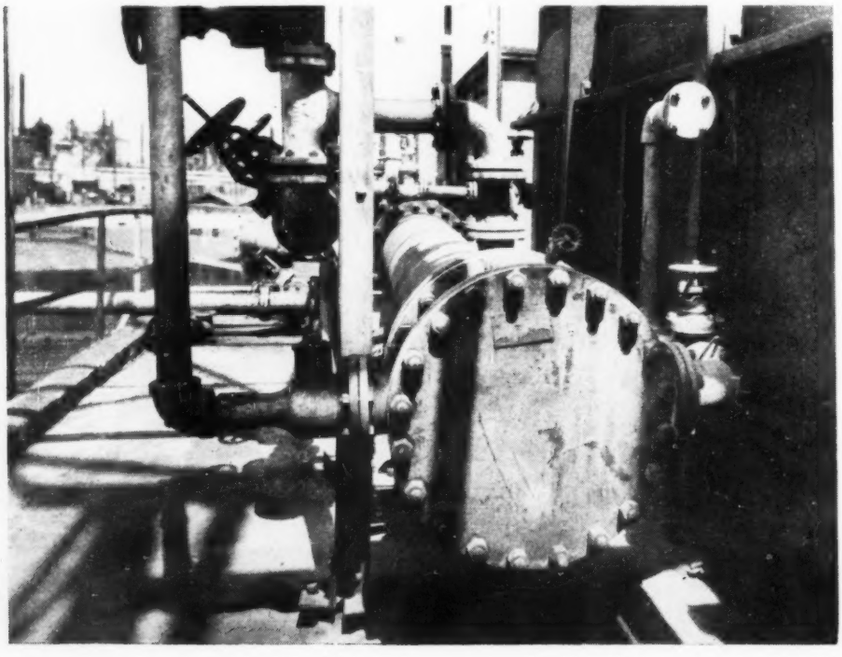

This cooler for naphtha, containing sulphides and chlorides with traces of phenol, has a ¼-in. thick 20 percent nickel-clad-steel shell, 11 ft. 8½ in. long by 23¼ in. inside diameter. Capacity 1500 bbl. per day

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Sodium Silicate Mud Used to Drill Deep Shale and Salt Water Zone

☆ **Directional deep well drilling through heaving shale and high-pressure salt water zones is simplified**

by C. C. Pryor, Associate Editor

PROPERTIES of the ideal drilling muds for control of heaving shale and control of high-pressure salt water zones, respectively, are similar in many respects. Such conditions of shale and salt water are usually encountered in deep wells as in the East Hackberry Dome field, Cameron Parish, Louisiana, in which a heaving shale—high-pressure salt water zone of Oligocene age was drilled in The Texas Company well, State East Hackberry No. 33. The shale though termed "heaving" is subject to severe swelling.

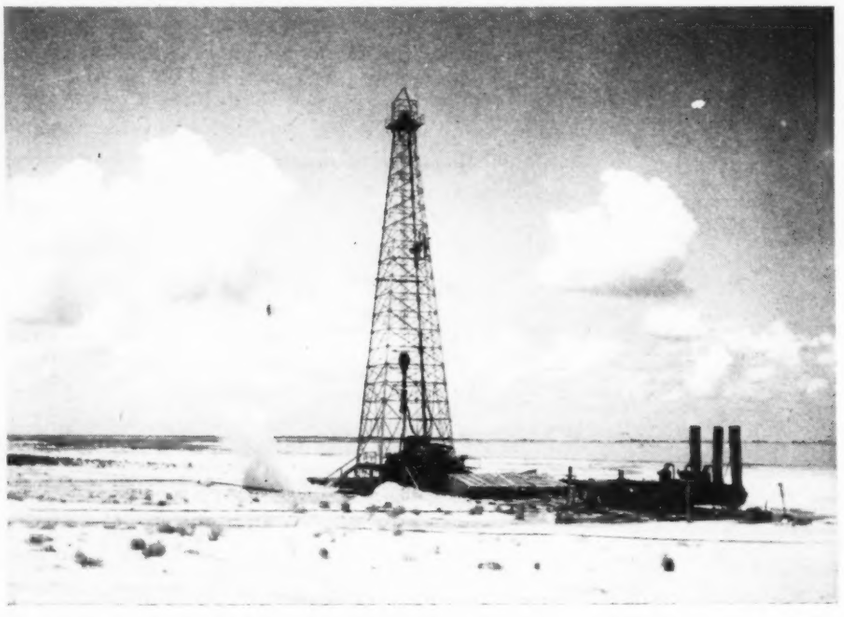
Previous Drilling

The formation of Oligocene age was topped nearly 10 years earlier in the East Hackberry Dome area. As it was possible to drill short depths into the series with water base mud, attempted drilling finally found close-in flank production. Deeper drilling on the northeast flank proved extremely troublesome due to the shale and high-pressure salt water encountered in four wells, three being drilled by The Texas Company and one by the Gulf Refining Company.

The drilling of the shale with water base mud was attended by using large quantities of mud-weighting materials and chemicals to control the rapidly swelling shales. Large make-ups while drilling were necessary due to high viscosity and gel strength difficulties. Chemical control was almost completely ineffective because of salty shales and high-pressure salt water.

Thus, the extremely hazardous nature of the drilling in No. 33, the possibility of sticking drill pipe, depth of the well, and great thickness of the heaving salt water shale zone, led to the decision to employ sodium silicate mud. Silicate of soda muds prevent hydrous disintegration and swelling of heaving shales, and they are particularly suited to supply the high mud weights necessary to balance the abnormally high formation pressures associated with salt water. The sodium silicate liquid weighs 11.8 lb. per gal., whereas ordinary water base muds start with water at 8.33 lb. per gal. This extra weight permits use of very heavy muds with greatly lowered content of suspended solids. Obviously, this feature permits easier control of the viscosity, gel strength, and other properties, making control of both the salt water and the shale simpler. Flocculation of drilling fluid due to the salt water is prevented by use of the sodium silicate and the mud protects the open hole, preventing sloughing of the shale, stuck drill pipe, bridging, and high-pressure gas blowouts.

General view of The Texas Company rig engaged in drilling State East Hackberry No. 33 in the East Hackberry Dome field, Cameron Parish, Louisiana



Drilling Mud

In the well, State East Hackberry No. 33, 11¾-in. casing was set at 2291 ft. Twenty-nine days later the hole had been drilled to 9000 ft. and was 200 ft. into the shale zone of Oligocene age. This portion of the well was drilled with 10-lb. per gal. water base mud except for the last 400 ft. when 11-lb. per gal. water base mud was used. Casing, 7⅝-in., 29.70 lb., was set at 8997 ft. with 1000 sacks of slow-set cement. Drilling was then resumed with a 6¾-in. hole after drilling the plug in the 7⅝-in. casing using a 14-lb. per gal. sodium silicate mud, which is unaffected by set cement. Viscosity of the 14-lb. per gal. mud was 45 seconds A.P.I., 35.5 seconds 500-500. Noheev[1] sodium silicate 48.1 percent (gram-volume percent), salt 10.8 percent (gram-volume percent), and the liquid phase or fluid loss 3.5 ml. per 30 min., 1/32-in. cake thickness.

Drilling progressed with the 14-lb. per gal. mud described above to 9309 ft. where a salt water flow with a slight show of oil and gas forced the operator to increase the weight of the mud to 15 lb. per gal. with Colox[2] as the weighting material. A further increase in weight of the mud occurred at 9556 ft. to 15.4 lb. per gal. when another show of salt water appeared with slight traces of oil and gas. At 9860 ft. the mud weight was cut from 15.4 to 13.2 lb. per gal. due to salt water and gas action. The weight was increased to 16 lb. per gal. using Magcobar[3] barytes.

[1]Noheev, a specially powdered silicate of soda for drilling mud manufactured by Philadelphia Quartz Company.

[2]Colox, manufactured by Baroid Sales Division of National Lead Company.

[3]Magcobar, manufactured by the Magnet Core Barium Corporation.

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The mud weight was further increased to 16.2 lb. per gal. at 9970 ft. and to 16.4 lb. per gal. at 10,002 ft. due to cutting action of salt water and gas. Mud of this latter weight and practically the same characteristics was carried to 10,336 ft., total depth of the well for the first drilling.

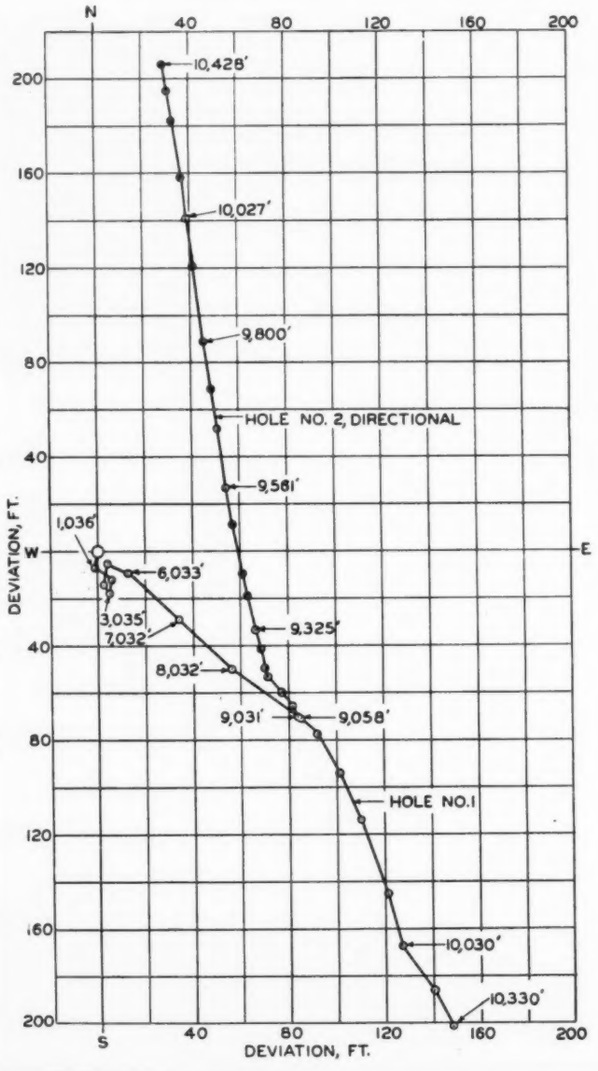
Deviation

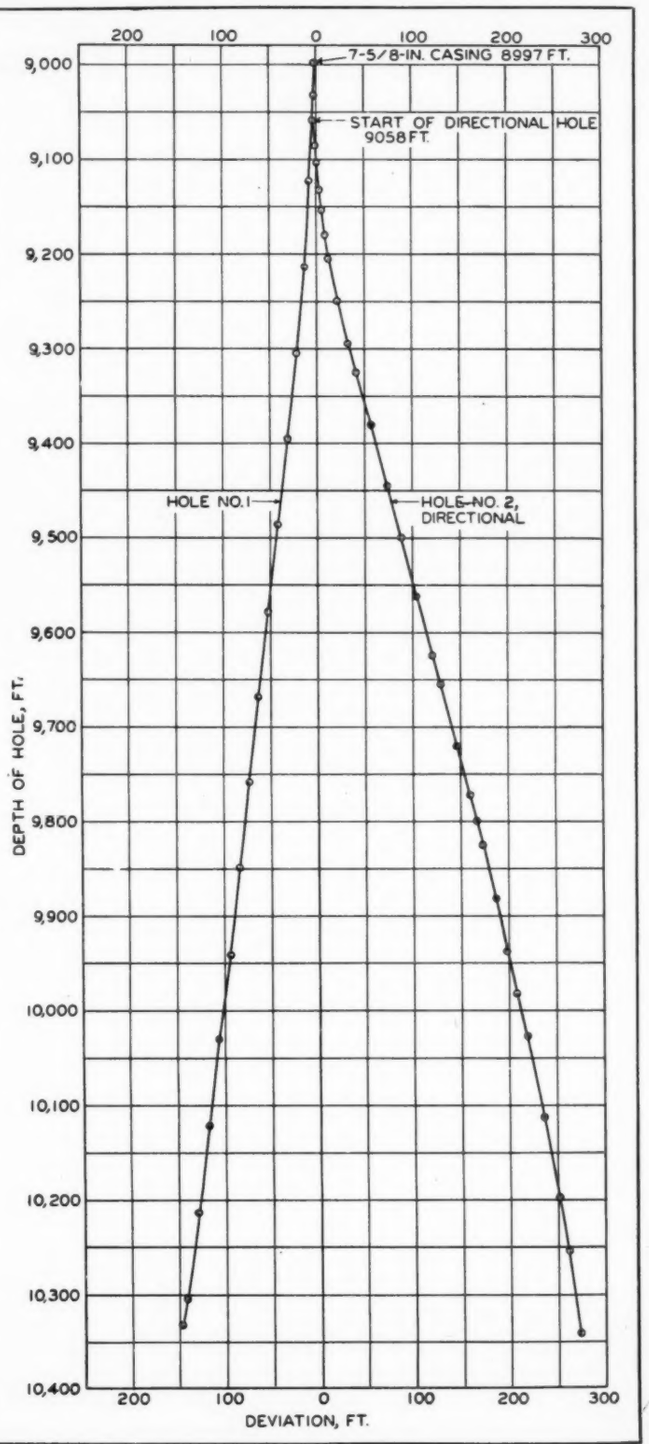
As shown by Fig. 1 the maximum deviation of the hole was 2 deg. 30 min. to 8997 ft. Below the 7⅝-in. casing deviation of the hole was toward the dome, which is the normal tendency in this section of the field. Other deviation recordings were made at 9304 ft., 5 deg. 15 min.; 9414 ft., 7 deg.; and at 9667 ft., 7 deg. 15 min.

From 9667 ft. the hole was drilled with extremely light weight on the bit to prevent further deviation; however, straightening the hole was impossible because of the strong tendency of the bit to drill perpendicular to the dip of the structure. This tendency has been observed in all the wells in this section. Deviation to about 6000 ft. is not pronounced and the hole tends to deviate away from the dome, but beyond this depth deviates toward the dome.

During drilling of the first hole, despite deviation, the high-pressure salt water and gas, and the hazardous characteristics of the shale, no difficulties were experienced with tight hole or bridging of the hole. All single-shot surveys and electrical logs were obtained without any difficulty. These simplified operations contrasted greatly with the difficulties experienced in the wells drilled with water base muds.

Fig. 1 (below) is a horizontal projection, showing the path of both the original hole and the directional hole. Data for plotting original hole to a depth of 10,330 ft. were obtained from a Sperry-Sun survey run to that depth. Data for plotting the path of the directional hole were calculated from the numerous single shot surveys taken. Fig. 2 (right) is a vertical section, below 9000 ft. showing the angle each hole deviated from normal while drilling. Data for plotting were calculated from Sperry-Sun survey and Eastman single shot surveys. Note the smooth dogleg of the directional hole as the angle is built up to a total of 17 deg. 45 min. in 267 ft.





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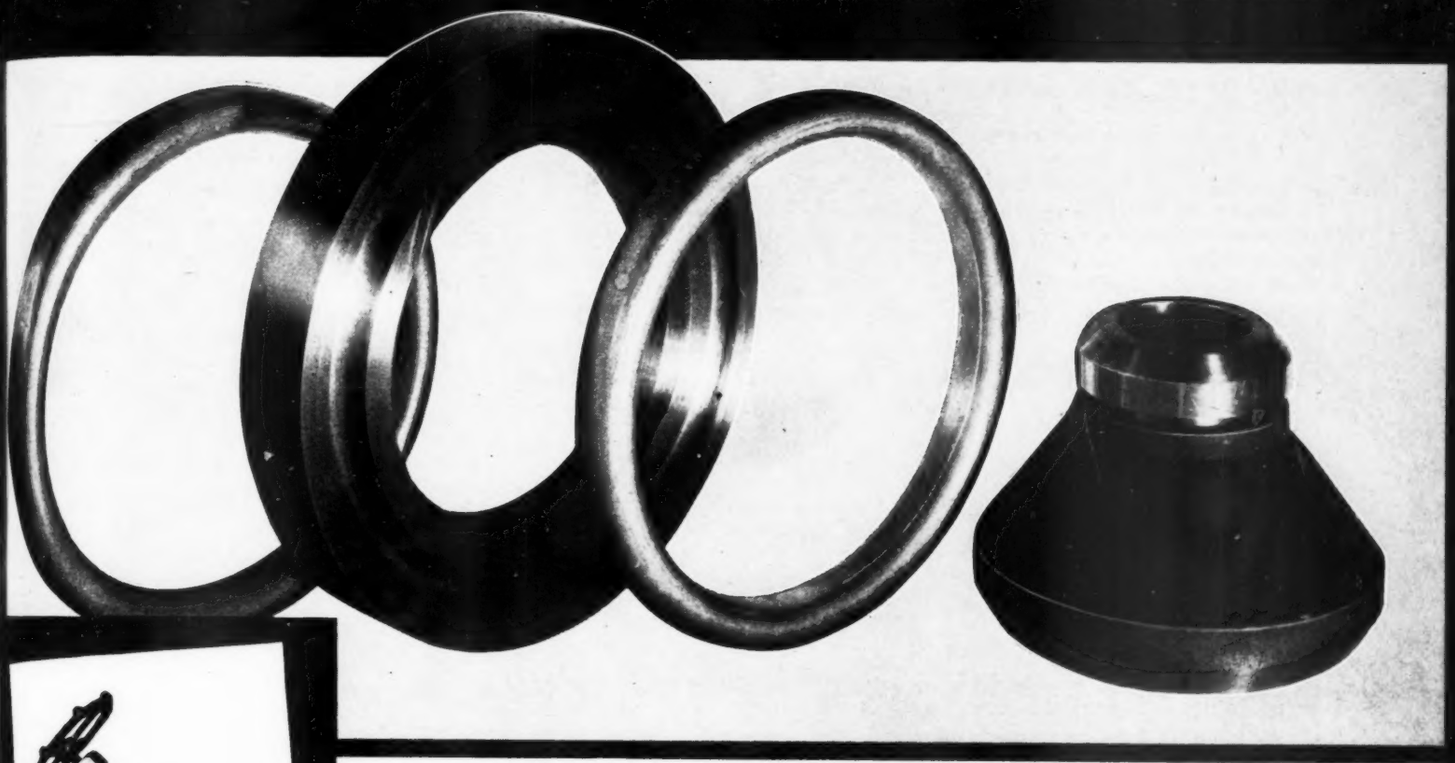

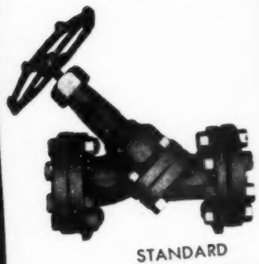

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HUNT *All-Steel Line Valves* feature a reversible disc and seat of stainless steel, which gives double the life of ordinary valves. The seat, or ring, is of a lower Brinell Hardness than the disc, assuring positive seal as the disc and seat wear. The same disc and seat will fit any of the various valves of the same size, whether screwed or flanged.

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Although the rate of bit penetration in certain shales is usually slower than with the water base muds, in this well a large portion of the reduced rate can be attributed to the attempt to decrease the deviation of the hole.

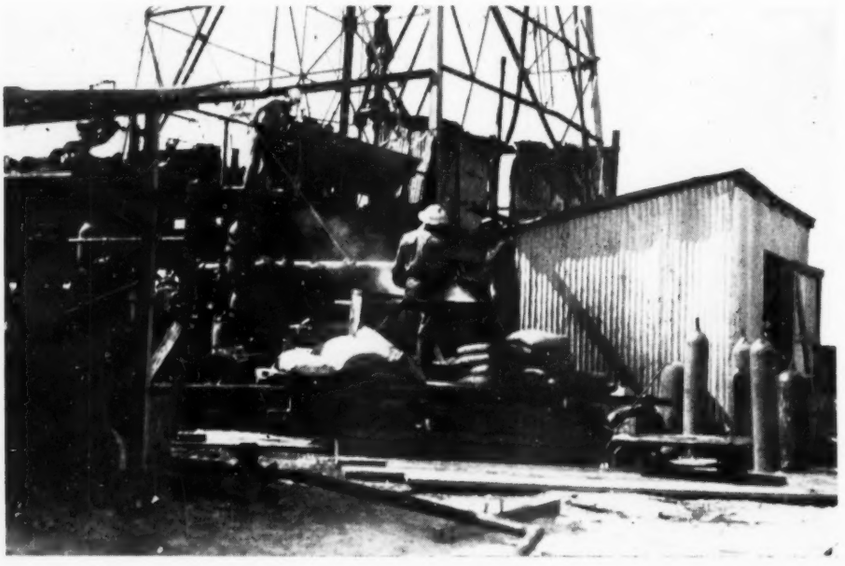
Drilling Mud Costs

The total mud cost for drilling the well to total depth of 10,336 ft. was approximately $14,000 as compared with a cost of about $25,000 for drilling other wells previous to No. 33 with water base mud, thus resulting in a saving on mud alone of about $11,000. Down time because of stuck drill pipe, fishing jobs for tools lost in the hole, etc. were entirely eliminated; also, the hazards of drilling the high-pressure zone were minimized because of the close control of the mud possible.

A definite distinction is made in the second drilling of the well as in this phase a definite objective was set by geologists. The knowledge that drilling in the field had been simplified and made comparatively safe, brought realization that wells could be successfully drilled in the section at reduced cost.

It is important to point out that the objective set by geologists for the second phase of drilling was obtained in a hole of greater deviation at a greater depth, and at a reduced rate of drilling because of whipstocking. Mud properties for practical purposes were the same in the second phase with the exception that the weight was higher at the beginning. Obviously, it was absolutely necessary that the hole be maintained in perfect condition for this second operation. The true gauge of the hole was evidenced by cuttings and volumetric considerations.

Mud mixing hopper with mud pumps in background on State East Hackberry No. 33. Building at right contains mud laboratory equipment



Second Drilling

Procedure in the second drilling consisted of pumping out 75 sacks of slow-set cement at 9250 ft. with the top of the plug at 8918 ft. The cement was drilled out to 9025 ft. and the plug side-tracked with a knuckle joint, followed by whipstocks in a 6¾-in. hole. Figs. 1 and 2 show operations. Bottom of the first hole was 250 ft. south 36 deg. east from the surface location. At 9025 ft., the bottom of the hole was 110 ft. south 48 deg. east from the surface location. The objective of this drilling was at least 150 ft. due north from 9031 ft. at depth of 9800 ft.

Actual new hole was made from 9058 ft., at which depth a whipstock setting was made and at 9085 ft. a single-shot survey showed 1 deg. N. 32 deg. W., or a total deviation of 2 deg. 45 min. The previous hole had shown a deviation of 1 deg. 45 min. S. 55 deg. E.

Procedure adopted in side-tracking the hole consisted of setting either whipstock or knuckle joint and drilling 10 ft. past the setting of the tool used. The 4⅝-in. rathole was then reamed to 6¾-in. with a pilot type reamer. Tools were then run into the hole without drill collars and 15 ft. of hole drilled. The 15 ft. of hole was then reamed with one drill collar and an additional 5 ft. of hole drilled. Then another tool was set and the procedure was repeated until the final angle of 16 deg. was obtained. Each operation of the tools gained about 2 deg.

Accomplishment of this procedure permitted the operator to run a 30-ft., 4½-in. drill collar in the hole in order to make the deviation angle gradual enough to eliminate abrupt "doglegs."

After the total angle of 16 deg. was obtained, three 30-ft. drill collars were used to maintain the angle, as a more limber hook-up would result in the angle dropping far too rapidly. So strong was the tendency for the bit to drill perpendicular to the dip of the structure that even with 90 ft. of drill collars, it became necessary to set knuckle joints and whipstocks at approximately 300-ft. intervals to maintain the angle.

At the objective point of 9800 ft. the hole was 164 ft. N. 4 deg. W. from the position of the hole at 9031 ft. At this point in the discussion it is interesting to note that in 267 ft. of hole in this shale that the actual angle of deviation was increased 17 deg. 45 min. That the increase in deviation was gradual is clearly shown by the smooth dog-leg in the sketch Fig. 2.

From 9800 ft. to 10,452 ft., the total depth of the hole, the deviation angle was allowed to drop gradually to 7 deg. 25 min. (See Figs. 1 and 2). At 10,428 ft. the position of the hole was 282 ft. N. 11 deg. W. from the position of the hole at 9058 ft. It was 208 ft. N. 8 deg. E. of the surface location.

No difficulties were experienced in drilling the second hole.

Conclusion

During the two drillings, especially in the second hole, the accomplishment of carrying a directionally-drilled hole would have been virtually impossible with almost perfect hole conditions. Cuttings obtained showed perfect bit marks. If a water base mud had been used the Oligocene shale would have gone completely into the mud and the wall would have swelled or heaved into the hole afterward, requiring reaming and washing, such as has resulted in other wells.

Whipstock setting or running of knuckle joints would have been extremely hazardous had the hole not been well conditioned. Use of the silicate mud resulted in each whipstock being set and retrieved and knuckle joints run without incident.

It was possible to land a short string of 5-in. casing on bottom and cement to the test sands drilled.

Results of drilling the two holes show the necessity of using a sodium silicate mud in operations involving extended controlled drilling in the shale in the East Hackberry Dome section.

The writer is indebted for the material, photographs, and charts to R. C. Wilkens, drilling foreman for The Texas Company at East Hackberry; O. W. Van Dyke, Philadelphia Quartz Company, Houston, Texas, and W. S. Howe, petroleum engineer, The Texas Company, Houma, Louisiana.

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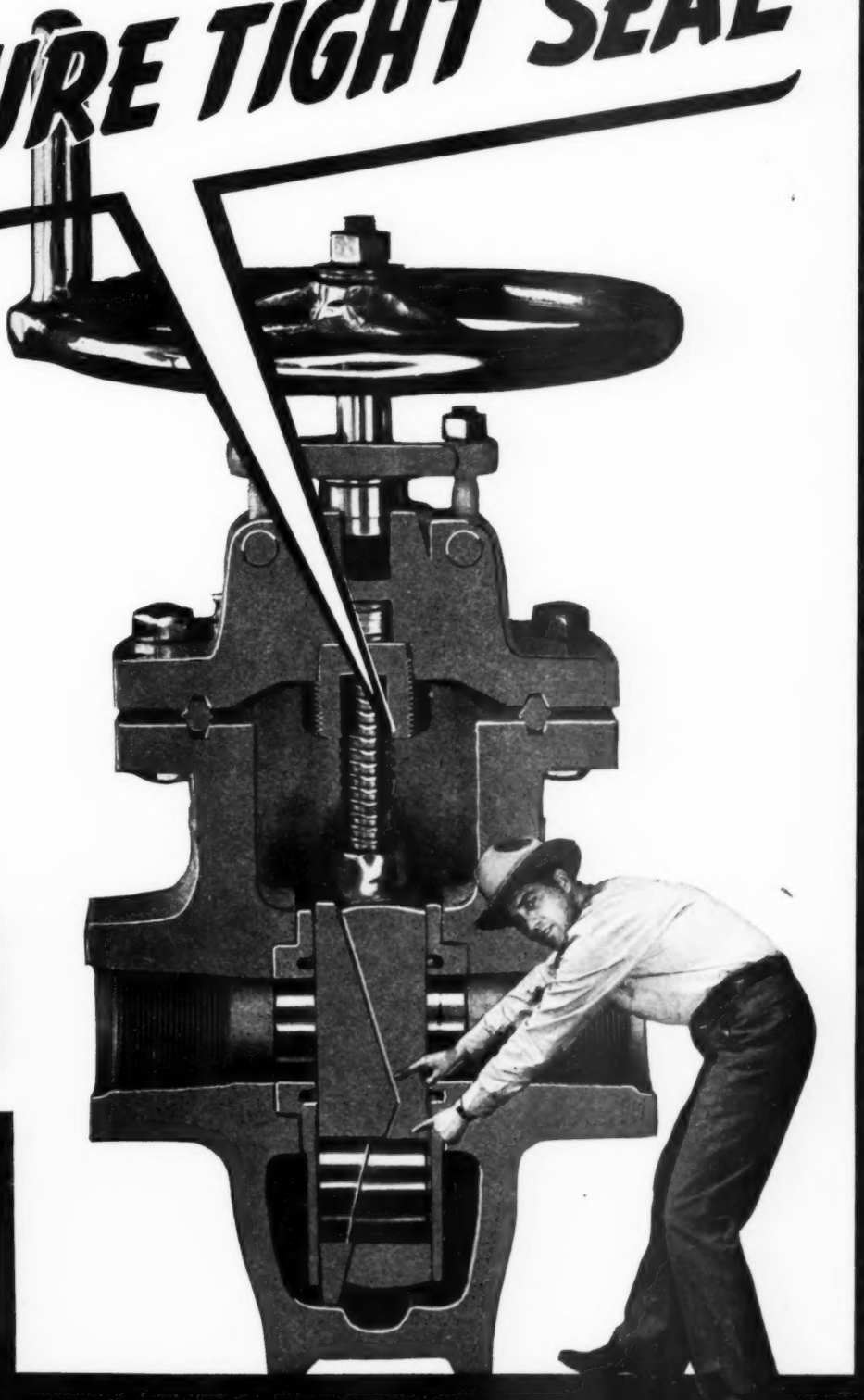

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☆ The detrimental effect of salty crude oil due to corrosion, coking, plugging, scaling, and the production of inferior products, obviated by proper desalting

AS CRUDE petroleum is produced from the well, it is usually accompanied by water in varying amounts. The water content, generally referred to as B. S. & W. or M. & B. S., obviously limits the utility of the crude as produced. Purchasers of petroleum place limits on the acceptable water content, such limits varying from 0.5 to 3.0 percent. In many cases, a premium is paid for the 0.5 percent oil, thus emphasizing the importance of a low water content.

The reduction in water content of the crude oil to meet the purchaser's specifications constitutes a major problem in production work, generally being accomplished by means of the electrical or chemical dehydrating processes; however, as complete removal is very difficult, a small amount of water usually remains in the oil when it reaches the refinery.

In the majority of oil fields, the water produced with the oil contains large amounts of dissolved salts. The oil-field waters encountered in connection with refinery desalting operations are brines that range in concentration of salts from that of sea water to virtually saturated solutions.

The salts found in these brines will vary according to the field from which the oil was produced. The chlorides are most abundant, but sulphates are also present in appreciable amounts. The most prevalent of the chlorides is sodium, with calcium and magnesium next in order. These salts, together with sulphides in some sulphur-bearing oils, can be found in practically all types of crude oil.

In Table 1 is shown the quantity of water extractible chlorides found in various types of oils that have been tested in Petreco laboratories. These oils were taken from refinery charging stock, and in some cases represent mixed crude being delivered by large pipe-line systems.

These tests indicate that the oil from practically all the large producing fields in the Mid-Continent, Illinois, and Michigan areas, as well as many others, contains large quantities of salt. It should be noted that the values in the table are for chlorides only, and do not include other salts such as sulphates, bicarbonates, etc.

All oils listed in the table should be desalted before charging to the refinery, if the adverse effects of salts are to be avoided. Determining the salt content of refinery crude stock is now routine in most refineries. This determination is not difficult, and one effective method is described later in this article.

[1]Material for this article obtained from Petroleum Rectifying Company of Houston, Texas, and Los Angeles, California.

TABLE I

Producing state	Type of crude oil	A.P.I. gravity	Cut BS & W	Salt per 1000 bbl.*
Arkansas	Schuler	33.7	0.3	77
California	Santa Maria	14.7	0.8	88
California	Ventura	28.9	0.6	64
California	Wilmington	18.0	0.7	102
Illinois	Illinois Basin	37.5	0.1	77
Illinois	Illinois Basin	30.1	4.0	1200
Illinois	Illinois Basin	30.2	1.0	318
Kansas	Mixture	34.1	0.2	47
Kansas	Kansas-Oklahoma mixture	34.4	0.6	112
Kansas	West Kansas	32.8	0.1	70
Kansas	West Kansas	36.8	1.3	238
Louisiana	Lake Long	40.7	0.2	20
Louisiana	Rodessa	39.7	1.2	256
Louisiana	South Louisiana	36.9	0.3	51
Michigan	Mixture	35.0	0.2	142
Oklahoma	—	19.4	0.5	87
Oklahoma	—	31.5	0.2	154
Oklahoma	—	19.3	3.6	1750
Oklahoma	Mixture	38.3	0.2	24
Oklahoma	Oklahoma City-Burbank	37.6	0.5	35
Texas	Panhandle	38.4	0.4	279
Texas	Gray County	41.5	0.8	336
Texas	Ector County	34.1	0.5	156
Texas	East Texas	36.9	0.6	130

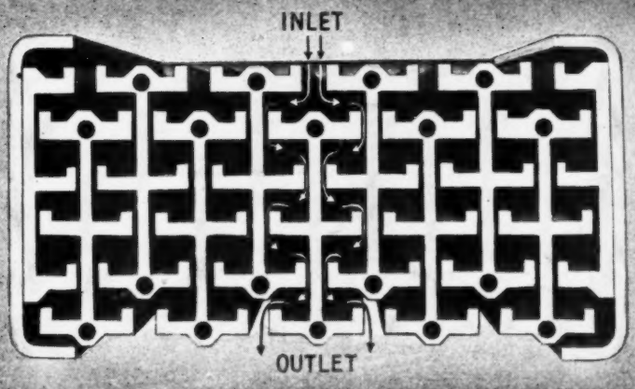
*Pounds of chlorides (as NaCl) per 1000 bbl. of oil.

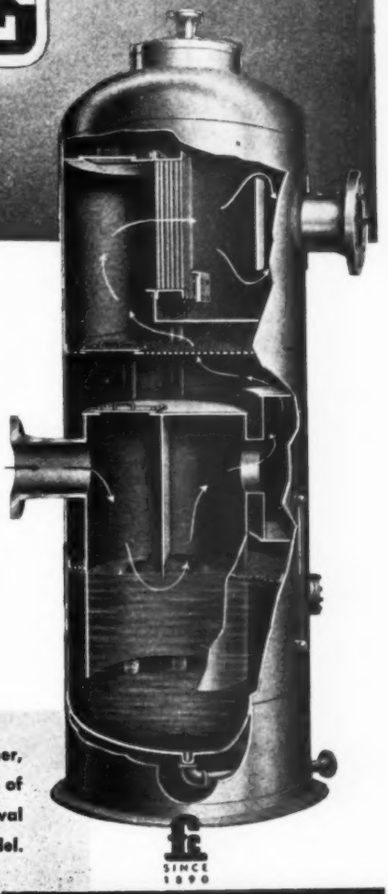
Corrosion

Corrosion is one of the most serious of the adverse effects on refinery equipment caused by a salty crude charge. The annual cost of corrosion in refineries is a major expense to which it is difficult to assign a total value as it includes many factors other than the direct cost of replacements and maintenance. Although much progress in combating corrosion has been made through metallurgical improvements and through development of neutralizing chemicals, neither of these procedures attacks the problem at its source.

The salts present in oils incompletely or non-desalted are a frequent source of corrosion in furnaces, towers, transfer lines, cooling and condensing units, and other refinery equipment. Therefore, the surest and most logical way to combat this corrosion damage is to reduce these salts in the refinery charge to the lowest possible value. Magnesium chloride in charging stocks readily decomposes at high temperatures, liberating the very corrosive hydrochloric acid. Calcium chloride undergoes similar decomposition, especially in the presence of the organic acids always associated with crude oils. Furthermore, repeated quantitative experiments in the Petreco laboratories have demonstrated that even so stable a salt as sodium chloride also liberates hydrochloric acid in the presence of suitable organic acids under distillation conditions. The percentage decomposition of the several classes of chlorides in crude oils (to form hydrochloric acid), when subjected to distillation conditions, depends upon the total chloride content of the oil, upon the nature of the salts present, upon the strengths and concentrations of the mineral and organic acids in the oil, to a certain extent upon the water content of the oil, upon the maximum temper-

New separator unit knocks out gas-entrained liquids and solids





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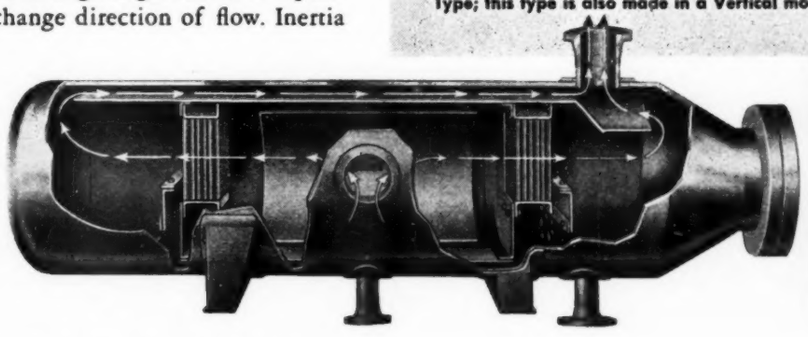
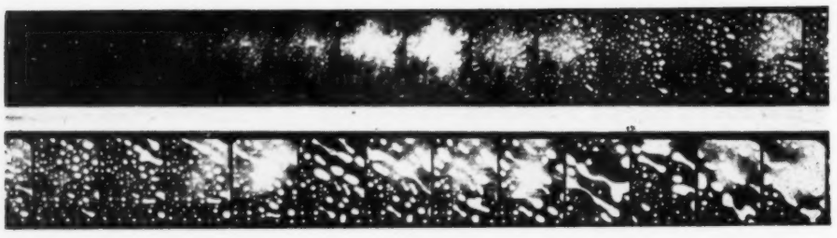
At right: Cutaway view of Fluor Gas Cleaner, Solids Removal Type. Below: Cutaway view of Fluor Gas Cleaner, Horizontal Liquid Removal Type; this type is also made in a Vertical model.



FLUOR GAS CLEANERS



This is a continuous photomicrographic high-speed film showing emulsion subjected to electric treatment. It shows the various stages (from left to right) of coagulation of the water particles in the emulsion.

ature attained, and on other refining conditions.

Heretofore it has been considered that refinery corrosion due to hydrochloric acid would not be appreciable when the oil contains a total of calcium and magnesium chlorides less than some 10 to 15 lb. per 1000 bbl. From the foregoing discussion, however, it is obvious that such amounts of calcium and magnesium salts can be highly corrosive. Although it is difficult to assign any arbitrary limit to the total salt content of an oil below which corrosion due to hydrochloric acid will not occur, it is certain that maximum chloride removal will result in a minimum of corrosion. The chloride content of an oil, below which appreciable trouble due to hydrochloric acid corrosion will not be expected, depends upon the nature of the salts present, the properties of the oil, and the refining conditions imposed. In any event, the tolerable chloride content will be relatively low and all charging stocks should be carefully tested for potential corrosion.

Hydrochloric acid corrosion of refining equipment is widely recognized as a serious and expensive operating problem. Obviously, a highly efficient removal is required in order to reduce salt content to the necessary low value. It is therefore most important to the refiner that a thoroughly dependable desalting process be employed.

Coking

Coking is another costly trouble caused by a salty crude oil charge. The deposition of coke in refining equipment, especially in furnace tubes and other cracking equipment, and also in shell stills and heat exchangers, is inescapable when processing crude oils at high temperatures. The coke from salty oils differs from that deposited from salt-free oils, and often the rates of deposition differ widely. The coke deposited from salty oils contains a relatively high percentage of salts, sometimes amounting to as much as 50 percent or more. These salts fuse on the metal and act as nuclei for the deposition of additional carbon. Such deposition materially decreases on-stream time and is very harmful to refining equipment. It retards heat transfer and promotes over-heating, blistering, and rupture of tubes. It is also harmful in accelerating hydrochloric acid corrosion, as the salts are retained in high concentration and in close proximity to the metal.

A further harmful effect of salts in the coke is that they serve to increase its hardness and density, thus increasing the difficulties in the cleaning operations, with consequent wear and marked reduction in equipment life, plus the increased time and labor costs.

Plugging

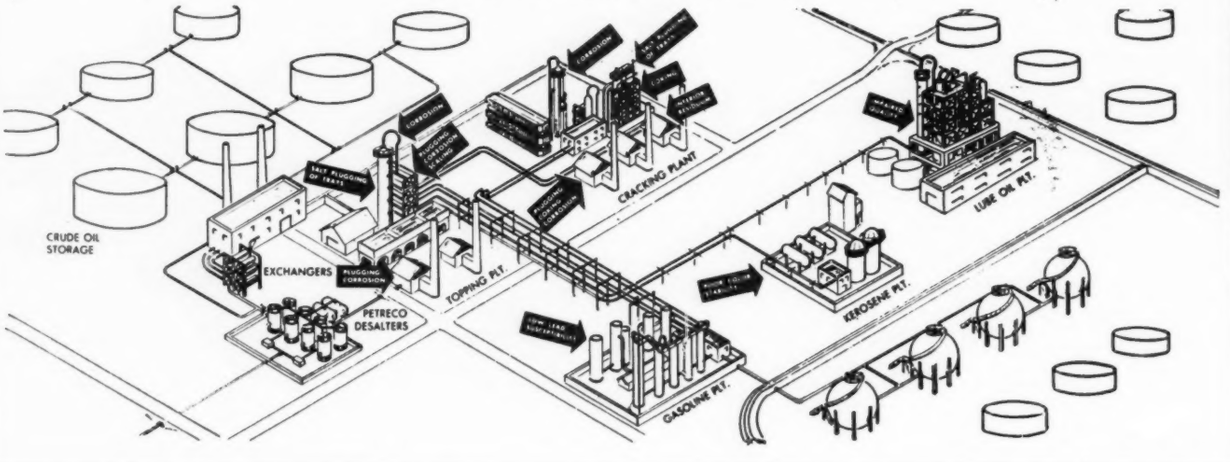
Plugging causes frequent shut downs for clean-out, and is one of the most severe process limitations imposed by salt. It is caused by the accumulation of crystalline salts in exchanger and condenser tubes. As these salts accumulate, the efficiency of the heat exchangers is impaired, and the retarded flow through the exchangers results in increased pressures on the refining equipment. Such plugging necessitates costly clean-outs and losses in on-stream time.

Scaling

Scaling is another process limitation caused by a salty crude charge. It results from the deposition of scale-forming salts such as calcium carbonate and calcium sulphate. These scales are extremely hard and build up on the inside of lines, condenser and exchanger tubes, curtailing throughput, retarding flow and preventing efficient heat transfer, and are very difficult to remove. Pieces of scale frequently become loosened and are carried along by the oil flow until they reach an exchanger where they lodge in the tubes and contribute to severe plugging.

When the charging stock is adequately desalted, the reduction in the deposition and hardness of the coke is often outstanding and results readily apparent. Plugging and scaling due to salt are virtually eliminated. Fuel consumption is reduced by maintaining high rates of heat transfer. With plugging eliminated, on-stream time is increased by preventing the build-up of high back pressures. Equipment life is

A Petreco desalting plant, located in the refinery stream as shown, will increase on-stream time and prevent many difficulties caused by a salty crude charge. The arrows indicate the most frequently encountered troubles caused by salty crude, at their points of occurrence



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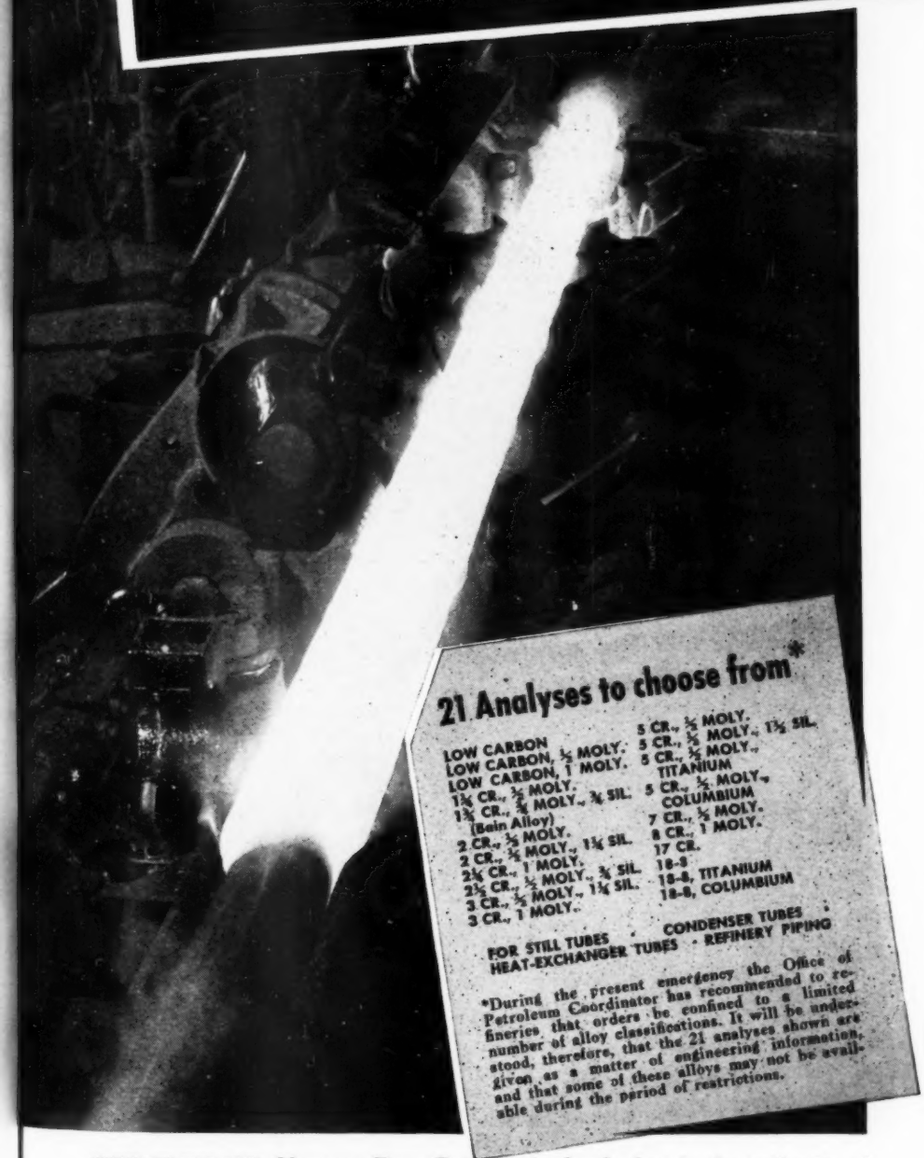
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7 CR., ½ MOLY.
8 CR., 1 MOLY.
17 CR.
18-8
18-8, TITANIUM
18-8, COLUMBIUM
FOR STILL TUBES
HEAT-EXCHANGER TUBES
CONDENSER TUBES
REFINERY PIPING
*During the present emergency the Office of Petroleum Coordinator has recommended to refineries that orders be confined to a limited number of alloy classifications. It will be understood, therefore, that the 21 analyses shown are given as a matter of engineering information, and that some of these alloys may not be available during the period of restrictions.

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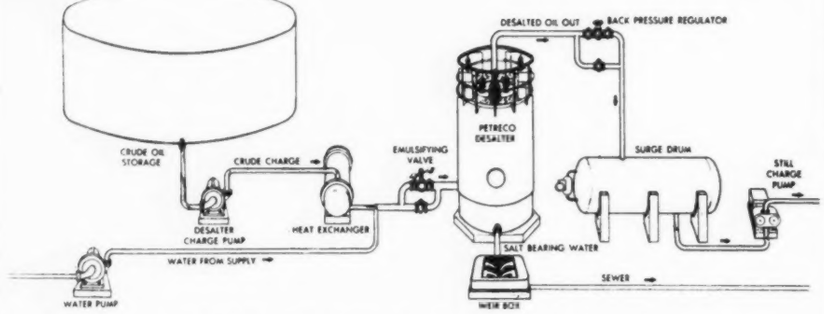
UNITED STATES STEEL



Typical flow diagram of a Petreco desalting unit

prolonged through the absence of overheating, acid corrosion, scaling, and over-stressing of metals. Cleanouts are fewer and less costly and incidental damage to equipment is minimized.

Although coking and corrosion exact their toll in equipment damage, high maintenance costs, and reduced on-stream time, there are further difficulties caused by the presence of salts. The effect of salts and other impurities on refined and residual products has been very definite in certain cases. This is particularly true in the case of asphalt. As asphalt is a residual product, the adverse effects of the salts are multiplied. As refining operations progress, most of the salts not changed to HCl or deposited in the equipment become concentrated in the residuum. Thus, a crude charge bearing 100 p.t.b. of salt often will give 400 to 500 p.t.b. of salt in the residual asphalt. Removal of salt from the crude oil reduces the insoluble matter, and enables the asphalt to meet stringent solubility requirements. It has been noted that in certain asphalts, manufactured for use as roofing materials, exposure to sunlight caused the asphalt to become brown when the crude charge was not desalted. One of the most important features of the removal of salts from the crude oil is that it imparts to the residual asphalt improved spot and ductility tests.

The lighter products also suffer from the effects of salt in the crude. Plugging and corrosion of vapor exchangers often causes leakage. When crude oil is one of the exchange media, leakage through the vapor side of the exchanger results in poor gasoline color. Beyond this, results obtained in certain refineries have indicated that gasolines from desalted crude showed improved lead susceptibilities. This was clearly demonstrated in one refinery where a considerable saving in tetraethyl lead was effected. Salty crudes have been found harmful to the quality of the resulting naphtha, kerosine, and other light products. In some instances desalting has greatly stabilized the kerosine color and improved the quality as indicated by the burn tests. Improvement in naphtha odor also has been cited as a result of desalting. In the refining of many light products, the amount of treatment required after distillation has been reduced materially by desalting the crude charge.

In the manufacture of lubricating oil, some salts may be carried over in the residual lube stocks. In some cases, salts have even been present in the finished products. Such pollution, of course, is highly undesirable and cannot be tolerated in high quality lubricants.

Fuel oil, when manufactured from salty crudes, will often carry a dangerously high percentage of salt. As it is a residual product, the bulk of the original salt content will be concentrated in the fuel oil. The desalting of crude oil has, in some instances, resulted in the production of fuels that have commanded premium prices over and above that previously obtained.

TABLE 2

Conversion factors for salts in crude oils

Mg. per liter (1)	Grams. per bbl. (2)	Lb. per 1000 bbl. (2)	Grains per U. S. gal.	Grains per B. I. gal.	Grams per metric ton (3)
1.	0.159	0.350	0.0584	0.0701	1.176
6.29	1.	2.20	0.367	0.441	7.40
2.85	0.453	1.	0.167	0.200	3.36
17.1	2.72	6.00	1.	1.20	20.1
14.3	2.27	5.00	0.833	1.	16.8
0.85	0.135	0.298	0.0497	0.0596	1.0

(1) Approximately the same as "Parts per million" (P.P.M.).
(2) 1 bbl. = 42 U. S. gal.
(3) For oils of specific gravity 0.85 (35° A.P.I., 34.7° Bé) at 60°F.
Note: When it is desired to compute approximate salt content of oils from analyses of the brine, it is necessary to multiply those results by 1/100 of the total water content (expressed in percent) of the oil.

Lost On-Stream Time

Corrosion, coking, plugging, scaling, and the production of inferior products are the most important specific difficulties for which salty crude is responsible, and their cumulative effect, lost on-stream time, is of greatest concern to refinery management. The cost of equipment replacements, made necessary by metal losses due to corrosion, is always accompanied by a shut-down for repairs, adding lost manufacturing time and labor expense to the replacement costs. Coking is even more harmful in its inroads on operating time. It not only necessitates frequent shut-downs, but also impairs heat tranfer and temperature control, and causes still pressures to rise excessively. Furthermore, when the coke deposited is hard and glassy, as is almost inevitable with salty crude, the power tool drill-out is accompanied by considerable metal loss from grinding.

Lost on-stream time is a serious and costly hindrance to refining operations, yet there has been a tendency to accept limited runs and periodic shut-downs when charging certain crudes as inevitable. Although metal inspections are recognized as a required safety precaution, frequent forced shut-downs for clean-out and repairs required by salty crudes are not necessary.

Analysis of Charging Stock

From these observations, conclusively confirmed by refinery experience in the oil industry everywhere, it is obvious that operation with a salty crude charge is costly and contrary to good operating practice. Frequent salt determination analyses of charging stocks should be made by the refiner to guard against the presence of salt in the crude oil. The Petreco standard test method is described below. It and other test procedures are also described in detail in the Petreco Bulletin "The Determination of Salts in Crude Oil," which is available on request.

Many methods have been suggested for extracting crude oil to determine its chloride content but the one described here has been found by Petreco to be suitable for many different types of crude oils and is therefore recommended for general use.

1. Measure 50 ml. of the oil sample, 50 ml. benzol, 25 ml. acetone, and 75 ml. distilled water into a 250 ml. cylinder. The oil volume should be accurately measured, preferably with a pipette that is rinsed with the subsequently added solvents.

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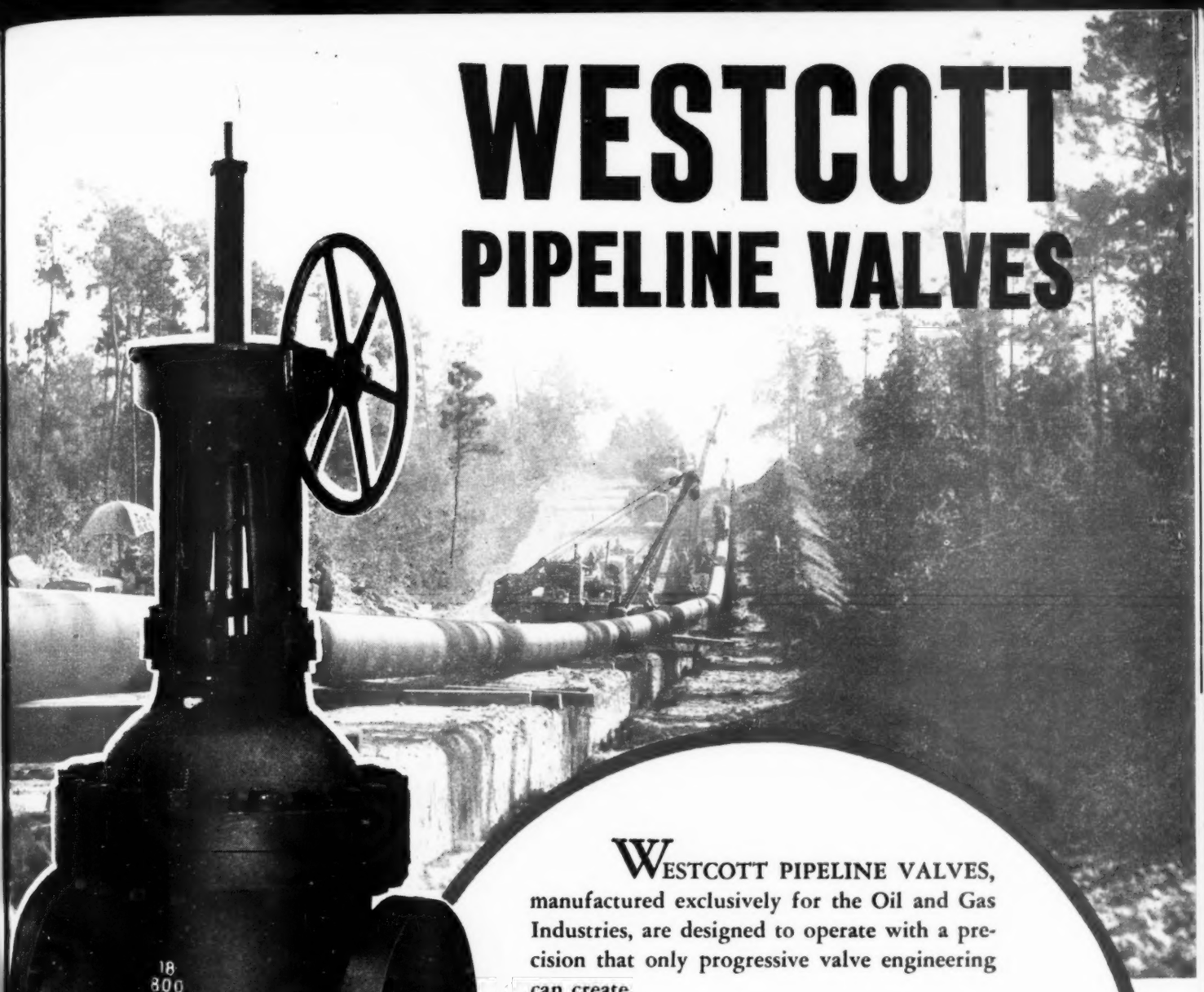

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2. Heat to 120°F. and emulsify thoroughly by agitating with a piston made of a brass rod to which has been affixed transversely a brass disk whose diameter is slightly less than that of the cylinder. A metal cylinder is advantageous for more expeditious heating. When the time is available, a short soaking period improves the initial extraction.

3. Transfer the contents of the cylinder to two centrifuge tubes, warm to 120°F., and note whether a fairly clear water separation has occurred. If not, add 1 drop of demulsifying chemical, Tretolite compound L 10,396 to each tube, and mix by shaking.

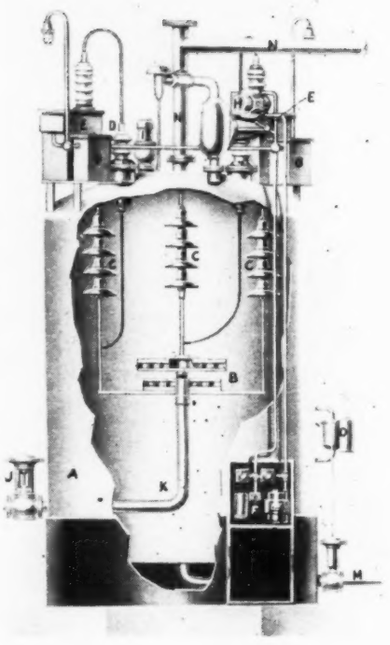
4. Centrifuge for 10 minutes at 1500-1800 r.p.m., and then siphon or pipette off all free water in the tubes through a filter paper into the titrating vessel. Take care that no sludge material is removed from the tube.

5. Add an additional 10 ml. water to each tube, heat to 120°F., shake thoroughly, and again centrifuge.

6. Remove the water completely to the filter previously used, and wash the filter with a little distilled water.

7. The extract obtained may then be analyzed for chlorides or other constituents by standard methods. For the determination of chlorides, the Mohr method may be used, but electrometric titration in acid solution is preferable because the nature of the extracts often causes color and other interferences in the former method.

The analytical results obtained in testing for salt content are variously expressed in terms of grams per bbl., lb. per 1000 bbl., or other units, depending on the basis upon which operations usually are conducted. In the United States, the preferred units are lb. per 1000 bbl. of oil of 42 gal. each. In order to facilitate conversion into any desired units, the accompanying Table 2 of conversion factors is included.



Typical Petreco electric desalter, cut-away view

Desalting Process

The Petreco Electric Desalting Process usually is employed at the beginning of the refining operation (see flow diagram), and utilizes relatively low temperatures and pressures. The process ordinarily is carried on at temperatures ranging from 140 to 220°F., a range usually available after the charging stock has passed through the first heat exchanger. Fresh water of approximately the same temperature is dispersed in the oil under controlled conditions, and the resulting mixture is immediately introduced into an electric field where the action of the electric current coalesces the original brine particles with the dispersed fresh water particles. The combined water quickly separates from the oil and is continuously withdrawn from the desalter.

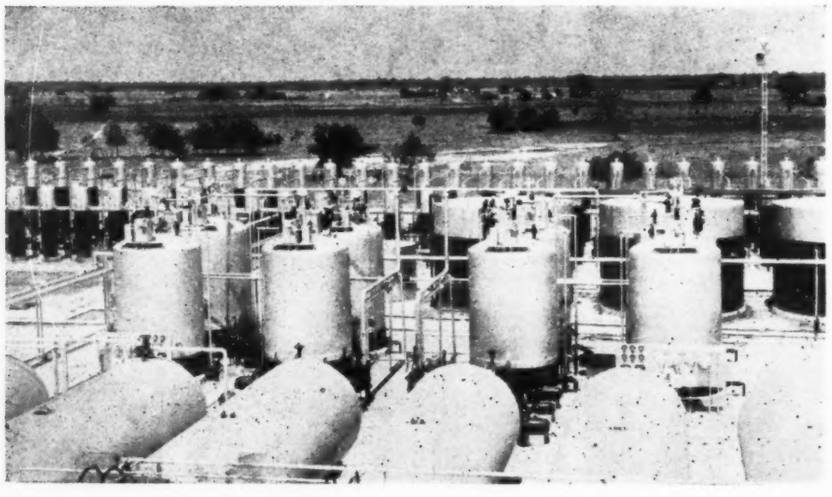
Petreco plants now operating in the United States have demonstrated the applicability of the process in the successful treatment of a wide variety of oils from various Gulf Coast, Mid-Continent, Illinois, and Michigan fields. The gravities of these oils have ranged from 17.8° A.P.I. to as high as 44.0° A.P.I., and the salt contents from less than 10 p.t.b. to more than 1700 p.t.b. In all instances the results obtained are remarkably effective, regardless of the type of oil being treated.

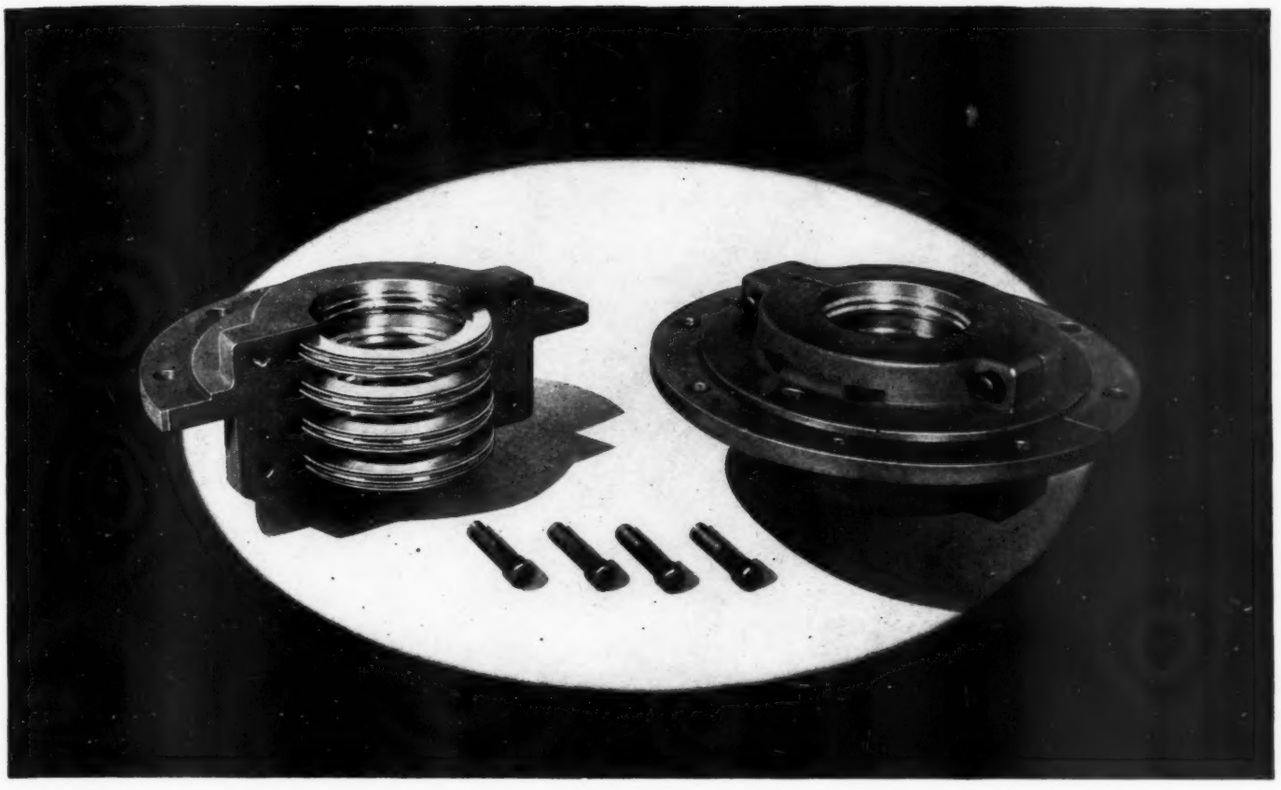
One essential characteristic of a satisfactory desalting process is that it be incorporated into the refinery system in such a manner that the charging stock may be treated "on-stream" without an intermediate prolonged settling period. The Petreco Process requires no separate settling step, the water separation taking place within the electrical unit. Desalted oil leaves the top of the electric unit and is charged directly to the refinery, while the water containing the extracted salts is continuously withdrawn from the lower portion.

Fresh water from available sources is employed for mixing purposes. Distilled water is not essential. as boiler feed water, waste water from the condenser boxes, or fresh well or river water are suitable in most instances. Exhaust steam is often used to bring the water up to the required temperature. The proportion of water used varies considerably with different charging stocks and the degree of salt removal required, satisfactory operation having been obtained with some oils with as little as 5 percent by volume of water, whereas with others as high as 20 percent is used.

The electric treater (shown on this page) consists of a pressure vessel 10 ft. in diameter by 12 ft. in height, having a volumetric capacity of about 185 bbl. The tank (A) is built according to A.P.I-A.S.M.E. specifications. In this vessel are suspended two or more electrodes (B), which form the treating field. These electrodes are held in position by suitable insulators (C). The requisite high potential is conducted through the treater tank by means of insulator entrance bushings (D). Special step-up transformers (E) are mounted on top of the treater tank, and are supplied with alternating current at 230 or 440 volts through a suitable control panel (F). Reactance coils (G) and automatic switches regulate the power going to the transformer, preventing overloads of the line and equipment. The transformers are rated at 5 kva. and commonly operate at potentials of from 16,500 to 33,000 volts.

An eight-unit desalting plant in Texas





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Among these developments are oil control packings, like the one shown above—packings which meet and satisfy the varied oil control requirements of enclosed crank case type Diesel, gas and steam engines, air and gas compressors, and pumps—packings that keep crank case oil out of the cylinders and prevent oil formations and carbon deposits and resulting stuck piston rings, valve failures, fouled inner coolers and receivers—packings that keep compressed air or gas free of oil—packings that pay their way many times over in oil and trouble saved.

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COOK'S METALLIC PACKINGS

An automatic switch (H) at the top of the treater serves to control the power to the unit so that when the liquid level is lowered for any reason, the power is cut off. Electricity thus can be delivered to the electrode system only when the treater is full of liquid. A pressure relief valve (I) contributes further to the safety of operation.

The crude oil and fresh water are emulsified by an automatically controlled and operated emulsifier (J), the resulting mixture entering the desalter via the inlet (K). The inlet piping conducts the mixture to the distributor (L), which releases the mixture so that it is immediately subjected to the electric field between the electrodes (B).

The action of the high potential electric field is to coalesce the added fresh water particles with the original brine particles in the oil. As this coalescence progresses, the combined fresh and salt-bearing water settle rapidly from the oil and are discharged through the water draw-off (M). The desalted oil discharges at oil outlet (N), flowing on through the refinery system.

A predetermined water level is maintained by an automatic gravity differential water level controller (O).

Numerous installations of the Petreco Process over a period of years have disclosed certain facts, as follows:

1. **High percentage removal.** In the majority of Petreco desalting plants the reduction of salts is to less than 10 p.t.b. and removal percentages are greater than 90 percent. About 25 percent of the Petreco plants are desalting to less than 3 p.t.b. and approximately one-half of the installations cite reductions to less than 6 p.t.b.

2. **Flexibility of application.** The process is equally well suited to either large or small throughput requirements. The individual daily capacity of a single unit averages between 1500 and 3000 bbl. and in some cases considerably exceeds the latter figure. Petreco plants, installed on the unit basis, are now being operated as multiple unit installations varying from one to twelve units. Special high capacity units are also available.

The unit plan obviates the necessity of making present installations "over size" for future expanded capacities as more units can always be added to handle unforeseen demands of increased capacity. Such additions can be accomplished at a minimum of design change and expense.

3. **Automatic operation.** Petreco desalters are automatic in operation and require only periodic inspection and operating attention so that no additional labor expense is involved.

4. **No additional heating.** As the desalters are usually placed in the refinery flow system somewhere after the first heat exchanger, no additional heat demands are made on the system. When it is necessary to raise the temperature of the wash-water, this is usually accomplished either by utilizing exhaust steam or by heat exchangers.

5. **Low power consumption.** The power consumption is very low, averaging about 48 kw-hr. per day per treating unit. Thus, on a unit processing approximately 2500 bbl. per day, the power requirements will average about 20 watt hours per bbl.

6. **Flowline processing.** The process is continuous, self-contained, and complete. The oil and water are mixed, the salt removed and disposed of, and the oil discharged into the refinery stream. No additional settling tankage is required and no appreciable flow interruption is involved.

☆

P 094.83

Maintaining Oil Circuit Breakers

by N. P. Wilson

Engineering and Service Department,

Westinghouse Electric and Manufacturing Company

TO prevent costly failures and delays in operation, it is important that the starting breaker function properly when an emergency arises. To accomplish this reliability, it is necessary that the breaker receive thorough inspection and maintenance periodically.

Motor starting oil circuit breakers are designed for general starting service. When properly applied they protect the motor from overloads, short-circuits, and guard against the sudden application of full voltage to the motor after it has come to rest.

The frequency of inspection and maintenance depends upon the severity of the duty that the breaker must perform and the condition of operation. Usually a light monthly inspection with a thorough inspection and maintenance semi-annually should be satisfactory. In some cases, however, breakers operating under very active and severe service may require more frequent attention. Other breakers that operate infrequently, and under less severe duty, will naturally require less attention. The frequency of inspection will be largely determined by experience.

Ten points to check for proper maintenance are as follows:

1. Before making any adjustment to an oil circuit breaker, make sure that all lines leading to it are electrically dead.

2. Be sure the breaker frame is grounded.

3. Do not operate the breaker excessively by the electrical operating mechanism when the oil tank is removed.

4. Examine all contacts frequently, especially after severe short circuits, to see that contacts are properly aligned. Dress or replace contacts that are burned.

5. After making adjustments, test the breaker by hand to make sure that it operates smoothly and correctly.

6. Inspect the oil regularly and after severe short-circuits. If it shows signs of moisture, carbonization or dirt, filter and retest it before replacing it in service. See that the oil level in the tanks is maintained at the proper height.

7. Remove all oil and thoroughly clean the tanks, tank liners, lift rods, and terminal bushings at least once a year.

8. Thoroughly inspect all bolts and nuts; tighten if necessary. Inspect all pins, links, and bearings for excessive wear. Check all cotter pins.

9. Dielectric tests of the oil should be made every three months, to show if it is reasonably good for circuit breaker work. Samples should not be taken until the oil has remained undisturbed for at least four hours. If testing for indication of water, take the sample from the bottom of the tank. For indication of carbon and after a heavy short-circuit, take the sample from the surface of the oil.

10. Arrange for regular inspection to see that the circuit breaker is in adjustment, the oil of good quality, and the complete breaker functions as required.

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Get pump barrels that are 4 to 8 times HARDER

One of Flupaco's new improvements in pump manufacture is an exclusive heat-treating method which has produced one-piece barrels with the unprecedented hardness measurements shown in the accompanying chart.

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Flupaco Hardened and Honed Pumps	627	64 to 70-C
Untreated Steel Pumps	150 to 170	6 to 14-C

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TO PRODUCE a pump that will outperform others in the same price class is, in itself, an important accomplishment. But to produce a pump that actually outperforms pumps selling at a much *higher* price is a real achievement.

Yet that's exactly what we have done in the new Flupaco "Hardened and Honed Groove Seals." What's more, "Groove Seals" are not just one-condition, one-depth pumps. They handle *any* job in the field where an insert (rod) type pump can be used—regardless of type of crude, volume depth, corrosion, abrasion, etc.—and have the largest cross-sectional displacement in insert pumps.

THE VOLUME PRODUCER handles a wide range of problems such as large volumes and deep pumping, sand conditions and corrosion, light and heavy oils.

THE PRODUCER "Groove Seal" is a rod pump for medium volumes and depths. Available in types, sizes and metals to meet almost every pumping condition.

"PETROL A" PUMPS* provide lowest-cost production from stripper wells

SAVING the cost of drilling new wells and making the most out of existing wells is made possible by the new, quality "Petrol A" Pumps, which can be...(1) installed at low first cost...(2) operated on minimum power... (3) depended upon for uniform production and long, trouble-free life.

"Petrol A" Pumps can be anchored to old liner barrels without pulling tubing. They can be made to run in 1½" insert tubing and are available in Top and Bottom Lock Types.

For all the advantages that you want in a stripper well pump—low first cost, low last cost, low per-barrel cost, uniform production and long life—investigate the "Petrol A" for its many benefits.

*1¼6" BORE ONLY

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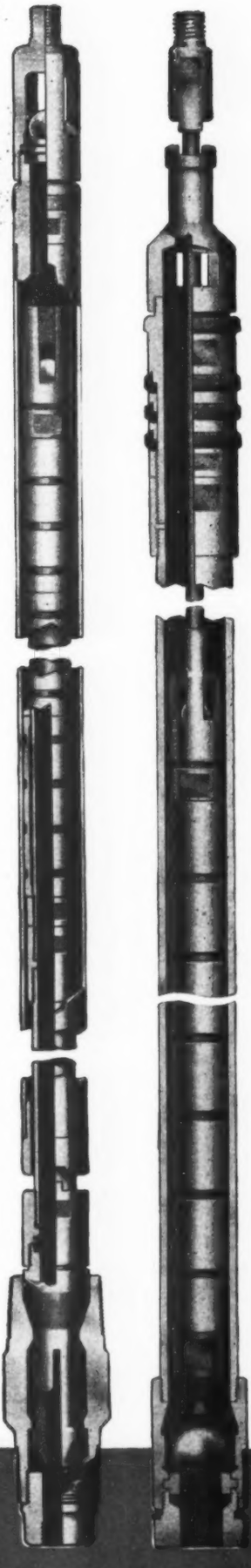

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Electrical Logging in Oil-Base Drilling Fluid

PETROLEUM ENGINEER Exclusive Feature

☆ Equipment developed to procure reliable electric log of a hole filled with oil or an oil-base fluid

by Wallace A. Sawdon

Pacific Coast and Foreign Editor

OIL IS a dielectric and, offering infinitely high resistance, carries no electric current. Oil-base drilling fluids, whether consisting entirely of oil or being compounded of oil with other substances, therefore interfere with electrical logging of a hole unless some means is provided to transmit the current from the formation to the electrode. Oil-base drilling fluids have come into rather extensive use to meet certain conditions, particularly in drilling through low-pressure sands where loss of water into the productive formation is detrimental. Equipment, therefore, has been developed to procure a reliable electric log of a hole when it is full of oil or an oil-base fluid. Such equipment also permits obtaining an accurate log of a hole full of fluid composed partially or completely of oil from a formation passed through or entered during drilling operations.

Drilling fluids made of native clays, with or without admixtures, or composed entirely of prepared bentonite and water provide adequate conductivity for electrical logging operations. Even distilled water could be used for drilling and an electrical log obtained with a standard type instrument, because of the readiness of water to dissolve various substances from the formation and thus become an electrolite. When using oil, however, it is a different matter. Most oil-water emulsions offer such high electrical resistance that no electrical formation logging can be done in such a medium without employing an instrument that will cut through the oil-mud film on the wall of the open hole and make a firm contact with the formations to be traversed. By means of this contact, maintained during the passage of the instrument through the formations being logged, the electrical properties of the formations are transmitted to the instrument.

Design of Instrument

One design of instrument that has been used successfully for electrical logging in oil-based drilling fluids during the last several years is shown in Fig. 1. In developing the instrument a study was made of the various kinds of formations that would have to be logged and of the many physical and mechanical features that would have to be incorporated in the design to procure a satisfactory record. As with the standard type instrument operated by the company making this oil-base fluid logging instrument, it is run on a steel-wire-shrouded, multiconductor cable previously proved for accuracy in depth measurement and durability in logging holes drilled with clay-water drilling fluid.

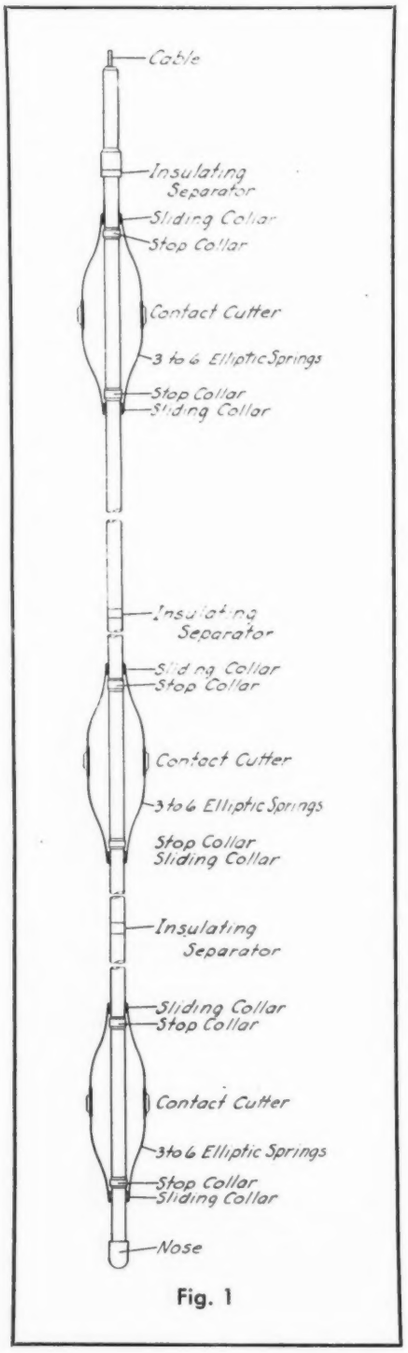

Fig. 1

The main consideration was the construction of a contact-type electrode sinker with a wide range of flexibility for different size holes and a sturdiness of construction to avoid hazard. The instrument requires sufficient weight to overcome the friction caused by the several contact points on each electrode, yet it must incorporate no features that will prevent it from being raised and lowered without coming out of the hole. Spacings comparable to standard electrical practices are provided but each electrode assembly must be electrically insulated from the other.

The individual electrode assembly includes from three to six elliptical springs with their ends attached to sliding collars that ride with a short range of movement on the main stem. Stop collars attached to the main stem prevent the spring assembly from moving beyond its proper space position. Each spring assembly has its individually attached conductor lead, which prevents the variable contact of the sliding collars with the stem having any influence on the recording. Each section of the sinker stem is electrically insulated from the other sections as indicated in the drawing.

The important feature of this construction is the oil-mud film penetrating cutter that is affixed to the high point of each of the elliptic strings. These cutters are made of hard metal like that used for hard-facing drilling

YOU can "MAKE" 100 Valves

without using a single pound of steel, setting up a plant, or hiring skilled workmen.

A pound of steel saved is a pound of steel made in these war days, and a valve saved is a valve made, too. That's why we say **you** can "make" 100 valves without using a single pound of steel, without using machinery or skilled workmen needed for other work. Through practicing valve installation, valve removal and valve reinstallation, a feature incorporated in the design of all GRAY Systems of Well Control, a single valve may be removed for use on indeterminable succeeding completions, rather than being left to rust away on the only well on which it was ever used. Valves are unnecessary for the attachment of flow lines to unused outlets, as the use of a removal plug permits the installation of valves as they are needed. Provision for repair and reinstallation is provided if and when valves become worn. Valves and other equipment are accessories with the GRAY Systems of Well Control, which may be used over and over again, removed when not needed, reinstalled when and where needed, and repaired when the necessity arises.

That such savings of control equipment are attainable with safety is evidenced by the successful completion of over 10,000 wells under working pressures up to 6,500 lbs./sq. in.

We invite your inquiry about the complete GRAY Systems of Well Control — our Composite Manifold, valve installation, removal and reinstallation under equalized pressure — how GRAY methods and equipment save steel — how **more strength with less weight** plus **simplification of design** gives **economy in the use of materials** plus **safety in the performance of hazardous operations.**

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HOUSTON, TEXAS

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bits. They are ground to a wedge and protrude approximately ¾ in. beyond the outer face of the springs. This construction insures a sufficiently firm, sliding contact with the face of the formations for the passage of electrical current.

The spacing of the electrodes is such as to provide either "detail" or "averaging" types of shallow penetration resistivity curves, natural potential curves, and deep or lateral penetration curves to a depth of penetration of 10 ft. into the formation to overreach possible infiltration of oil from the drilling fluid.

The instrument is thus designed to eliminate the partial or even complete opening in the circuit caused by a poor or completely interrupted contact at a given point during the logging of a well due to the oil or oil-base fluid carrying no electricity. This is particularly true when logging shaley sections that are generally firm, homogeneous, and good electrical conductors. In the oil-bearing formations there is the combination of a non-conductor in the drilled hole and a non-conductor placed by nature that fills the pores of the reservoir and forms a film around the individual sand grains. There are thus marked differences between the oil sands and shales shown in logs of this type. Correlation with logs of adjoining wells that have been taken in clay-water fluid have not, however, been difficult.

Types of Logs

Two different types of electrical logs run in oil-base fluid are given in Figs. 2 and 3. The one in Fig. 2 shows the "detail" or "point electrode" type of shallow resistivity curve. It was made according to standard practice followed in the San Joaquin Valley fields with the natural potential on the left and the resistivity curves on the right and shows the shales and sands in "hourglass" presentation.

The log shown in Fig. 3 is one using the averaging type normal resistivity curve. It was made according to standard practice followed in the Los Angeles Basin fields. The resistivity curves are on the left and the natural potential curve on the right with high resistivities and voltages throwing to the right from their respective base values of shales.

Concurrently with the increased use of oil-base drilling fluids has been a greater study of various kinds of mixtures making up the fluid. Research and laboratory experiments have been conducted by several of the major companies to determine the most satisfactory oils to use and the best solids to add to the oil to give weight and better viscosity as provision against caving and sloughing as well as to insure removal of cuttings with the returns. Commercially prepared admixtures have also been developed for this purpose. A number of oil-base fluids have proved their ability to seal-off sand sections against loss of oil from the fluid into the formation and some of the later formulas have eliminated the disagreeable features that accompanied the use of oil-base drilling fluid. The improved types have aided in the logging operations and with the use of these types little or no settlings have been encountered at the bottom of the hole to throw off the measurements.

Data for the compilation of drawings and information used in the description of the instrument here discussed were supplied by A. Maclay Gardner of Lane-Wells Company.

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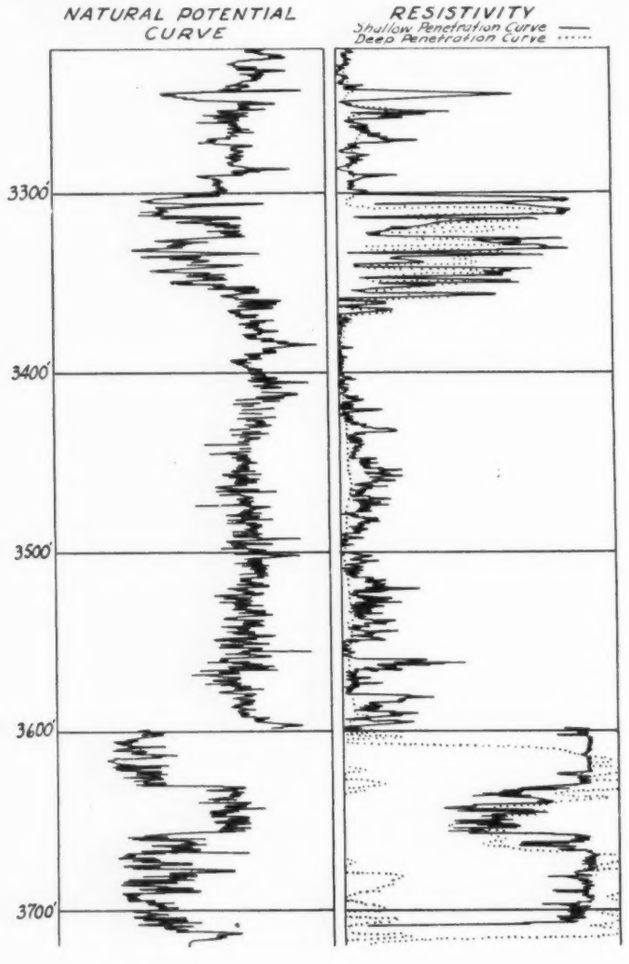
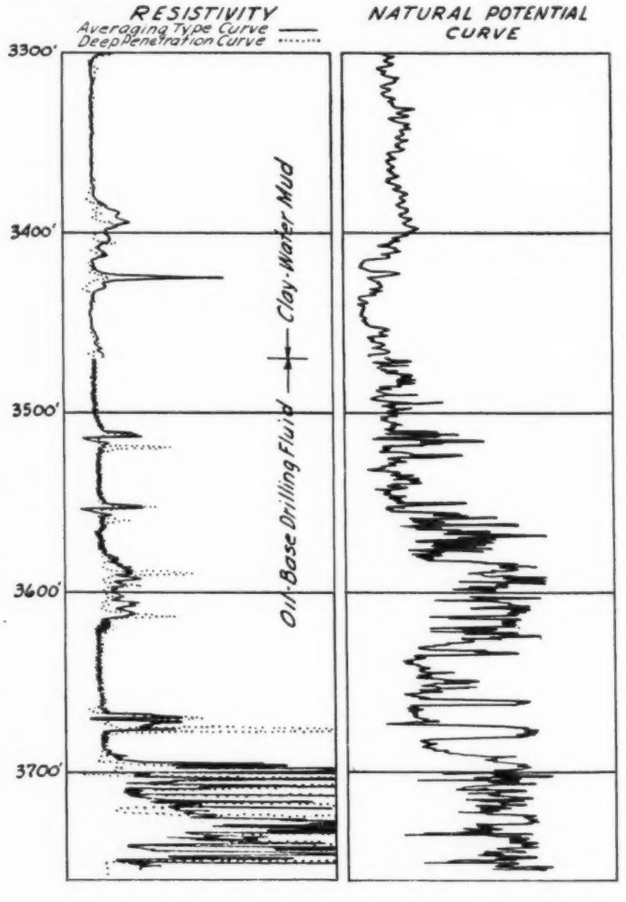
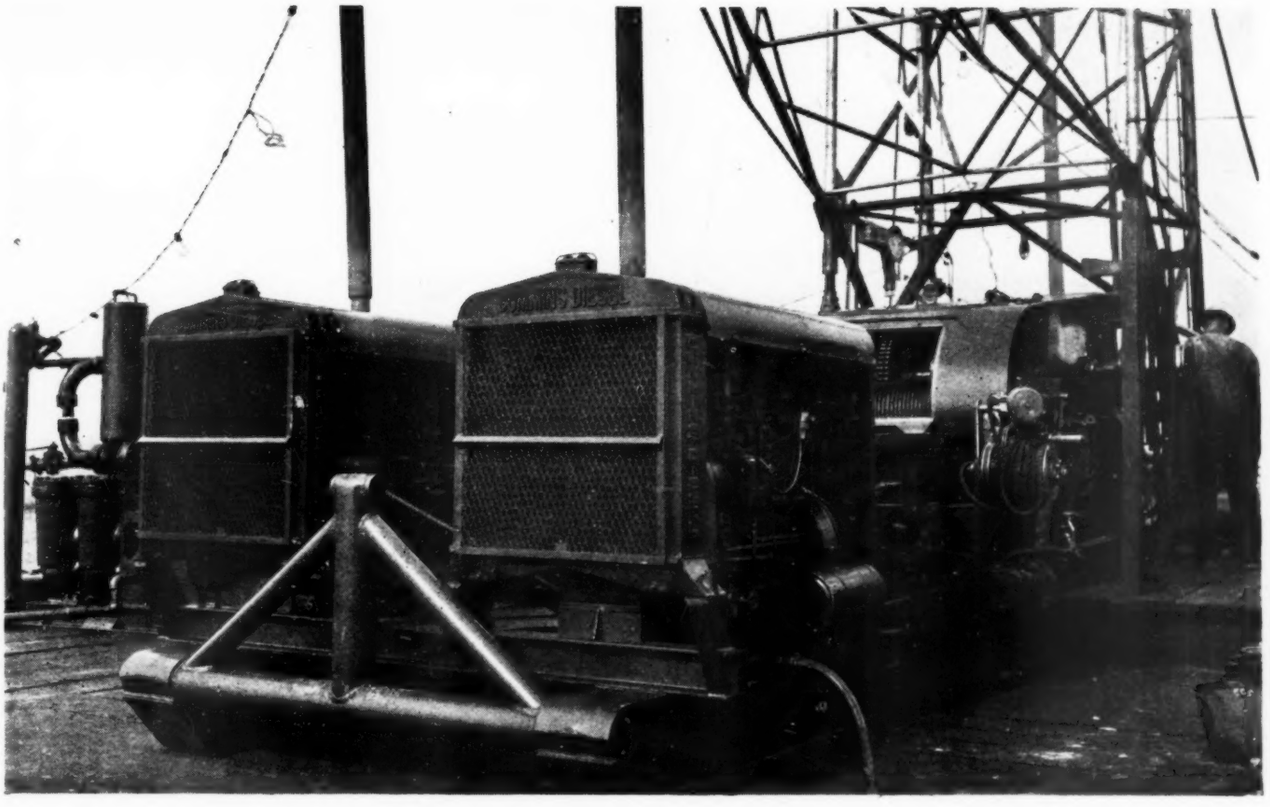
Fig. 2 (left)
Fig. 3 (below)







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(Photo courtesy The Barrett Division, Allied Chemical & Dye Corp.)

When the Arkansas River overflowed its banks and inundated the surrounding countryside the "Big Inch" pipe line sprang a leak. The exact nature of the break is not known as the river is still at flood stage

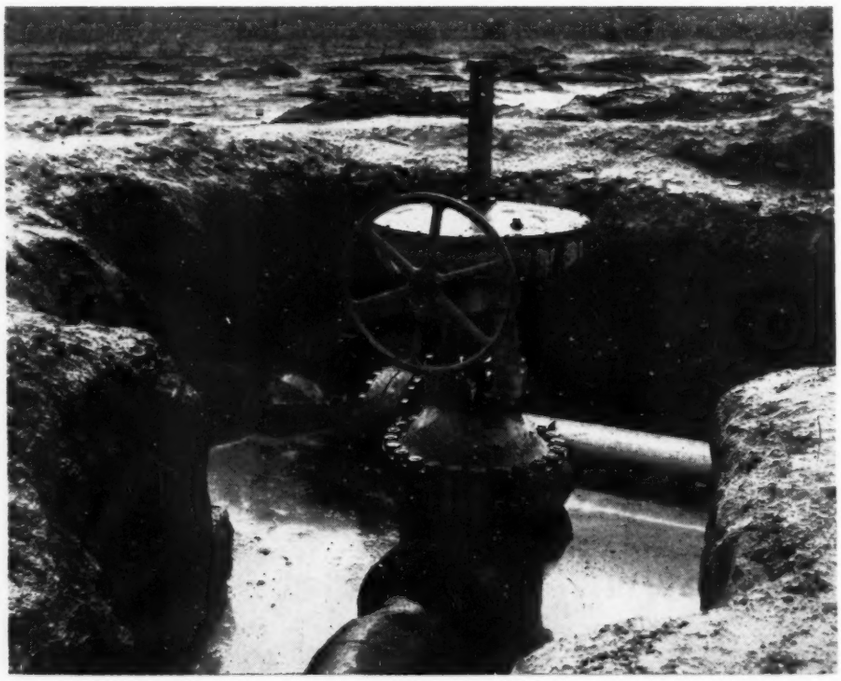
River Crossing Break Repaired In Record Time

PETROLEUM ENGINEER Exclusive Feature

by Frank H. Love
Managing Editor

WHEN flood waters caused a break in the "Big-Inch" line at the Arkansas River crossing in May, prompt action by the operating personnel of War Emergency Pipelines, Inc., and the construction contractors, Williams Brothers, reduced downtime to a minimum. Twenty-three minutes after the break occurred the line was shut down, and in seven days less 2 hours and 50 minutes crude oil was again flowing to the East through this vital artery. In actual point of working time the repair was made in 99 hours, the remainder of the seven days being consumed in getting materials, equipment, and workmen assembled.

The break occurred when the river reached a level of approximately 29 ft., knowledge of the break coming with a drop in line pressure. A study of intake and discharge pressures at the sta-



The pipe was cut on both sides of the river near the gate valves and the ends bull-plugged (see left of picture)

Spring is a Symbol

Spring is a symbol of things to come.... It marks Nature's victory over the harshness of winter, gives new assurance that the violence of war must some day yield to the blessings of peace.... When that day will come no one can say, but this would seem to be certain: The more we give now in sacrifice, effort and money, the sooner will we regain the luxuries of peacetime existence.... All of Gaso's facilities are now engaged in war production. . . . Gaso Pump & Burner Mfg. Co., 902 E. First Street, Tulsa, Oklahoma. Export Office: 149 Broadway, New York. Los Angeles: Service Oil Field Supply Co., 5333 S. Riverside Drive.

GASO PUMPS

FOR EVERY OIL INDUSTRY NEED

(Photo courtesy Barrett)

Due to the high water level a temporary loop was laid to get the line back in operation as soon as possible. The line was laid down one side of the river, up and across a railroad trestle, and back the other side to tie-in with the main line. These photos show the 45-deg. bend that carries the pipe onto the bridge

tions revealed the approximate location of the break, a plane was chartered, and by flying the line the exact location was determined.

Due to the high level of the river, which subsequently reached a 30-ft. crest, a permanent repair to the crossing was impracticable and a temporary installation was made. The line broke on the north side of the river and about 1000 ft. back from the bank the 24-in. line was cut near the gate valve and bull-plugged. Twenty-inch pipe was welded into the line, this size pipe being readily available as the War Emergency Pipelines' 20-in. products line is being laid in the vicinity. The temporary line was laid aboveground to a point where a 45-deg. bend carries the pipe upward to a railroad bridge, on which it is supported across the river. On the south side of the river the line extends to the point where it connects with the main 24-in. line. The end of the 24-in. line on this side of the river also was cut and bull-plugged.

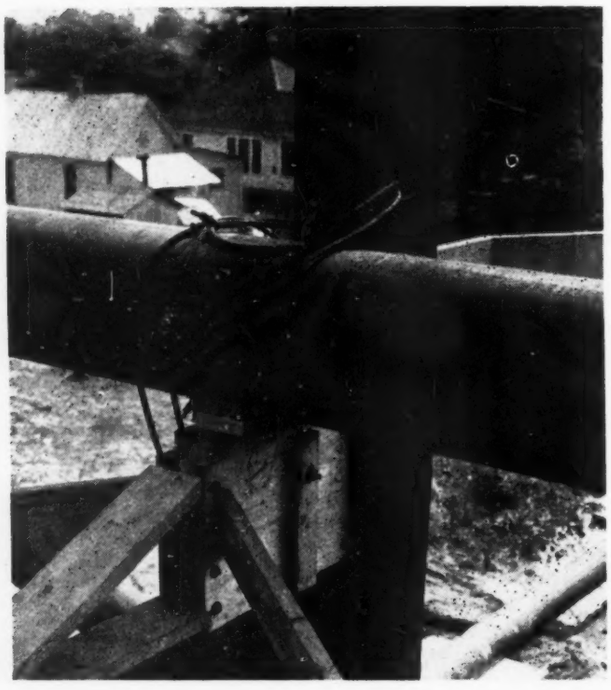
On the railroad trestle the line is supported by wooden blocks and steel cable looped around the pipe and I-beams of the bridge holds it in place.

Due to the promptness with which the line was shut down very little crude oil was lost, and the speed with which the repair was made had oil again flowing through the line in record time.

☆ ☆ ☆

On the bridge the pipe is supported by wooden blocks and a steel cable is looped about the pipe and tied to the I-beams of the bridge (see photo at left). Picture at right shows welders making the last bead—the repair has been made

(Photo courtesy Barrett)



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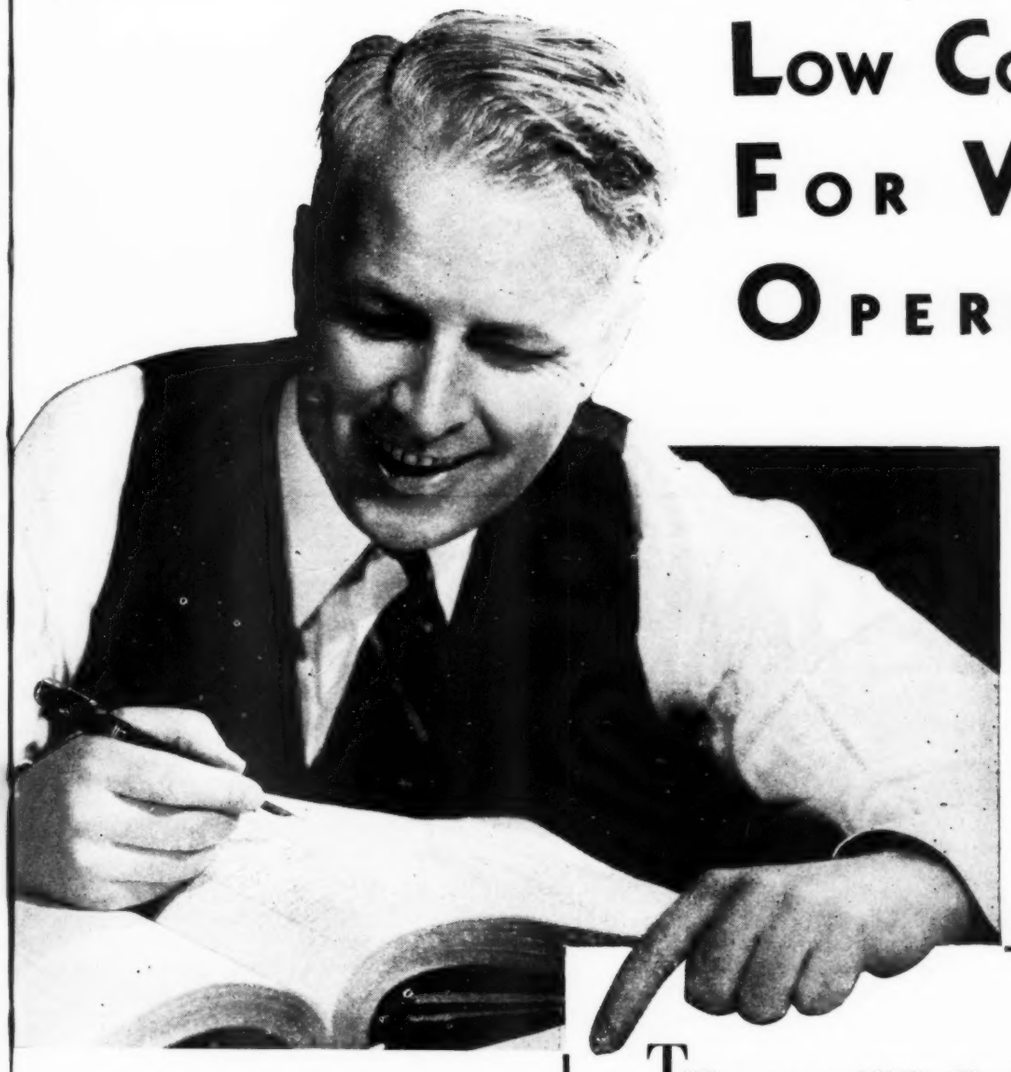

THE economy of Utility Electric Power is nothing short of amazing, particularly during this period when practically all other costs have skyrocketed.

The economy factor is one important reason why Utility Electric Power has been specified for an ever increasing number of war projects in the petroleum industry as well as industry as a whole.

Of course, Utility Electric Power is proving highly efficient wherever it is used, else top-flight management, engineers, field superintendents and other key men would not insist on its installation.

Mr. Operator, these are important things to keep in mind so when critical materials become more available, and expansion begins in the petroleum industry, you, too, can benefit by the advantages of Utility Electric Power. It's not too early to investigate further now!

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Check air gap and varnish coils. Keep worn out parts for exchange on new purchases.

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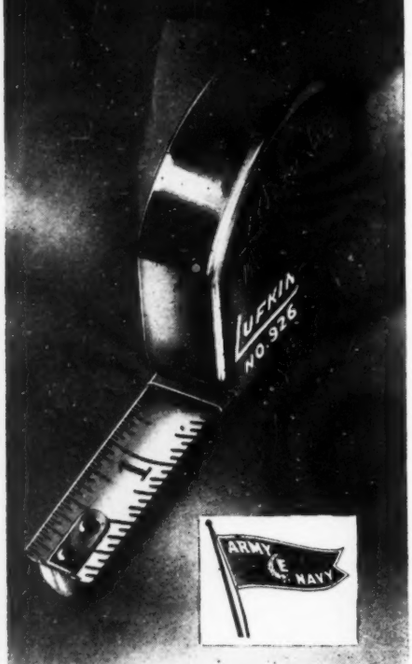

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"Honey, I will give you a quarter if you will kiss me."

"OK," says she, "go ahead." (Lapse of a few minutes.)

"I will give you a dollar if you will let me put my arms around you."

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"As soon as the first ray of the sun comes in my window."

"Isn't that rather early?"

"No. My room faces west."

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With the seriousness of present oil situation in mind—you can be sure of maximum performance and safety with DIAMOND Roller Chain Drives on all your equipment. DIAMOND CHAIN & MFG. CO., 441 Kentucky Ave., Indianapolis, Indiana. Tulsa Office: 2238 Terwilleger Blvd.

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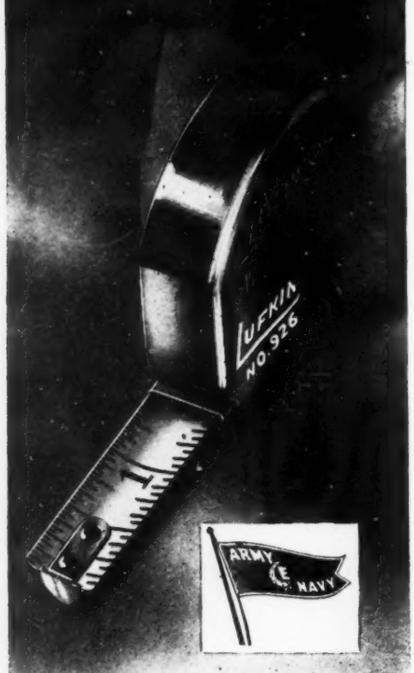

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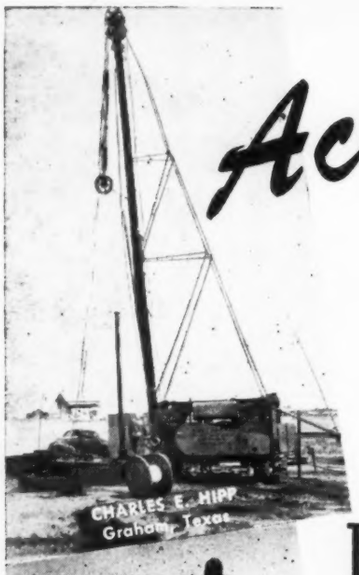
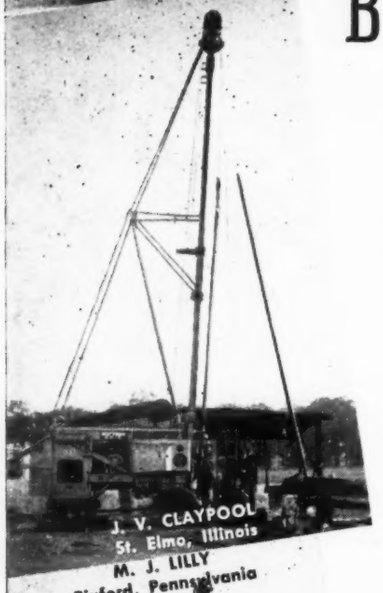


BUCYRUS-ERIE SPUDDERS

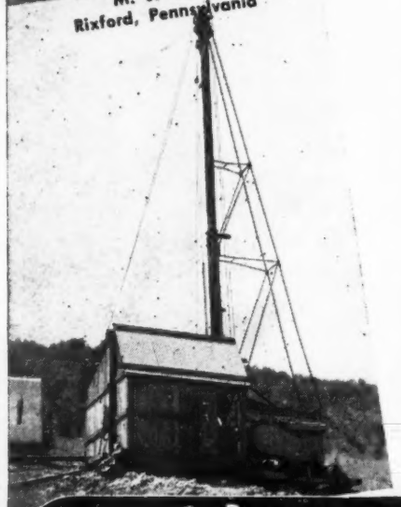


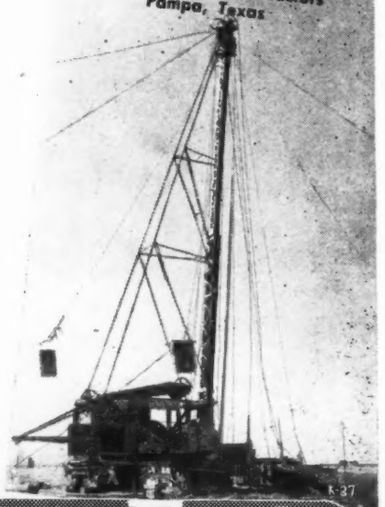
Since their introduction into the oil fields only three years ago, the highly mobile, all steel Bucyrus-Erie Spudders have established an outstanding reputation for versatility. All over the country they are setting new records.

So popular are these rigs that repeat orders are common. A prominent drilling contractor in Illinois has purchased seven; two Texas contractors have each bought three; another contractor in Ohio has two; a concern in West Virginia has five; and there are many others who also own at least two, some of them more.

With this proof that Bucyrus-Erie Spudders have gained wide acceptance in the oil and gas fields, you can put one or more of these rigs on your jobs with every confidence that they will stand up to the exacting service and constantly varying conditions encountered.

Begin preparing now to meet your postwar drilling problems. Look over the Bucyrus-Erie Spudders—machines that have *proved* themselves in all types of oil field service. Watch them at work. You'll understand why they've made so many friends.





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Bucyrus-Erie employees have accepted the award of the Army-Navy "E" as a challenge to keep production rising. * *

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The Continuous Tables have developed as a result of suggestions for new tables, direct contributions, and improvements to existing tables by members of the petroleum and related industries, including manufacturing concerns, who are continually searching for practical information reduced by computation to tabular form readily applicable to the problems daily confronting them that might otherwise necessitate a more or less tedious calculation. These contributions and suggestions from the industry have resulted in a valuable exchange of information and data contributing to the progress of the industry as a whole.

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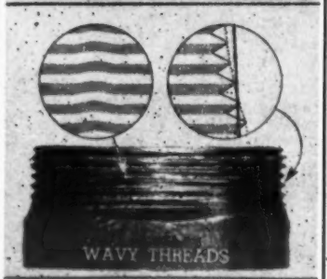
CHART FOR CORRECTION OF PIPE THREAD TROUBLES*

When threads look like these	Hand Threading		Machine Threading	
	Inspect for...	Correction	Inspect for...	Correction
ROUGH THREADS	Dull chasers (Check by inspection.)	Sharpen	Dull chasers	Sharpen
	Insufficient lubrication (This not only makes poor threads but damages chasers.)	Use plenty of good oil (Sulphur base threading oil plus little lard oil gives good results.)	Insufficient lubrication	Flood with good oil (Sulphur base plus little lard oil gives good results.)
	Improper lead shape (Usually due to improper grinding.)	Grind properly	Improper lead shape	Grind properly
	Excessive or insufficient lead cutting angle	Grind to correct angle	Improper lead cutting angle	Regrind to proper angle
	Broken tooth in chaser	Grind out entire tooth	Broken tooth in chaser	Grind out entire tooth
	Chasers not set to form true cutting circle	Clean slots—set chasers to true cutting circle—grind chasers to make them of uniform length	Chasers not set to form true cutting circle	Correct setting
SHAVED THREADS	Improper lead of chaser	Regrind lead	Improper lead of chaser	Regrind lead
	Chasers not tracking properly	Keep slots clean	Chasers not tracking properly	Keep slots clean
	Chasers not set in due rotation	Correct setting	Chasers not set in due rotation	Correct setting
			Carriage travel retarded	Repair carriage
 WAVY THREADS	Die or chasers not set true	Center die or chasers	Loose chasers (Play in slot lets chasers tilt, increasing clearance.)	New die head
	Thumb screws not tight	Tighten screws with wrench		
	Worn-out lead screws	Get new die stock	Worn cam in die head (Check lost motion due to worn cam.)	New die head
	Cuttings or dirt in chaser slots	Keep slots always clean		
	Pipe ends not square (Die starts on same angle as end cut, and threads diagonally. This trouble often wrongly blamed on "out-of-round" pipe.)	Cut pipe end square to axis of pipe and rethread	Misalignment of die and chuck	Check and re-align

*This table may be filed under P 432.4 or 622.21

Do's and Don'ts in Threading

Don't try to work with dull tools. No craftsman can do good work with poor equipment.

Don't put new or sharpened chasers in a worn stock, and expect to get first-class results. After the stock is worn out, it should be discarded.

Don't skimp on oil—either in quantity or quality. Good oil pays dividends in better work, and longer die life.

Don't try to use a set of chasers after long use or abuse has impaired its precision. Discarding worn out chasers is sound economy.

Don't forget to center accurately the die and tighten the thumb screws WITH A WRENCH in hand threading, and don't forget to line up the pipe properly in the grips in machine threading.

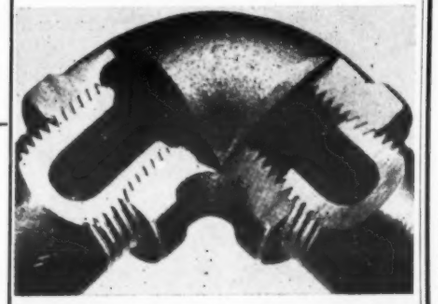
Be sure to clear slots of all dirt, gummy oil, chips, etc., when you change chasers. Keeping tools clean lengthens their life.

Be sure, when the chasers are reground, that it is done by someone who knows how, or who will accurately follow directions. Wrong grinding can ruin chasers, spoiling a multitude of threads.

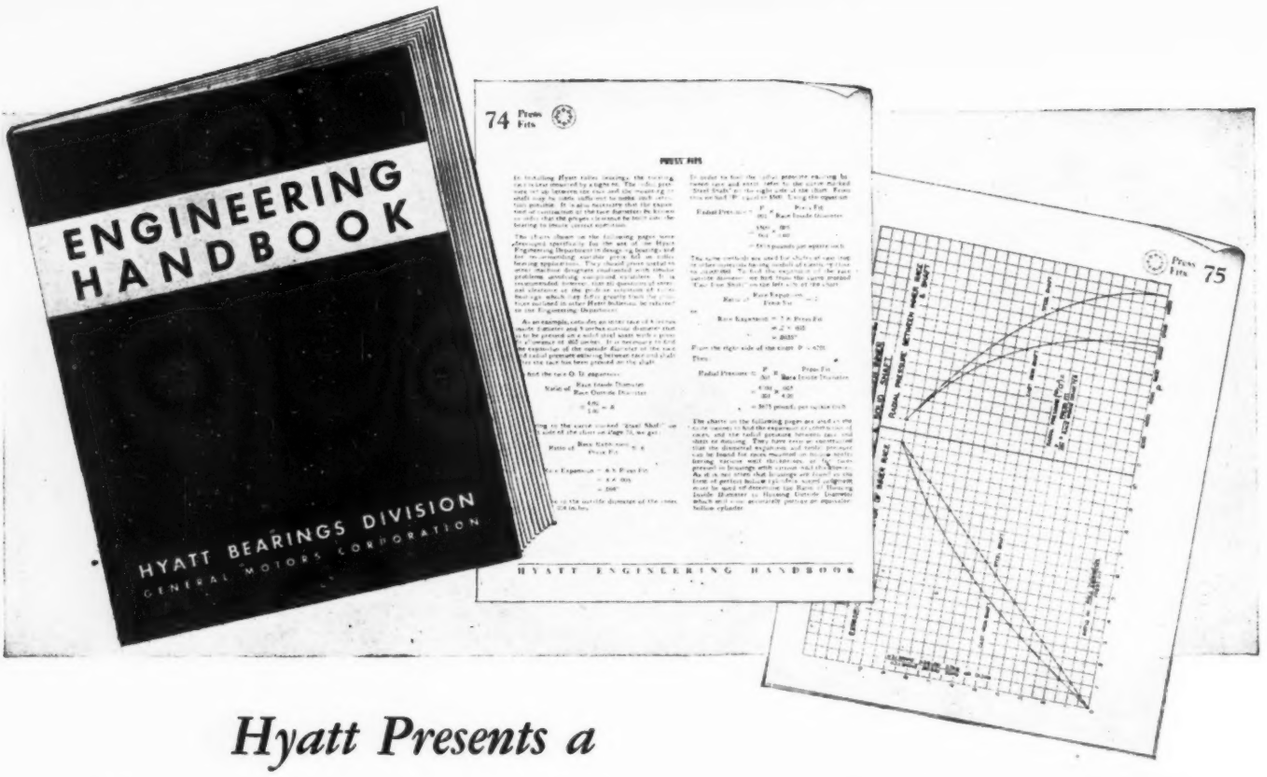
Be sure that the pipe ends are cut off square and true. Give the die a fair chance, so it can start on straight.

When trouble occurs, check up your equipment carefully. It may be that the trouble is something that a little adjustment will fix. In any case, the difficulty can be corrected with a minimum of cost and lost time.

And finally, cut the thread long enough to engage fully the threads in the fitting. A thread like the one illustrated below, is too short to resist mechanical forces caused by expansion and contraction, vibration, and so forth.



Material supplied by A. M. Byers Company, Pittsburgh, Pennsylvania



Hyatt Presents a

TIME-SAVING, WORK-SAVING SERVICE

for Engineers and Designers of War Products

Just as Hyatt Roller Bearings are helping to speed up Victory in war equipment and in the machines that produce it, now the new Hyatt Engineering Handbook is in the fight.

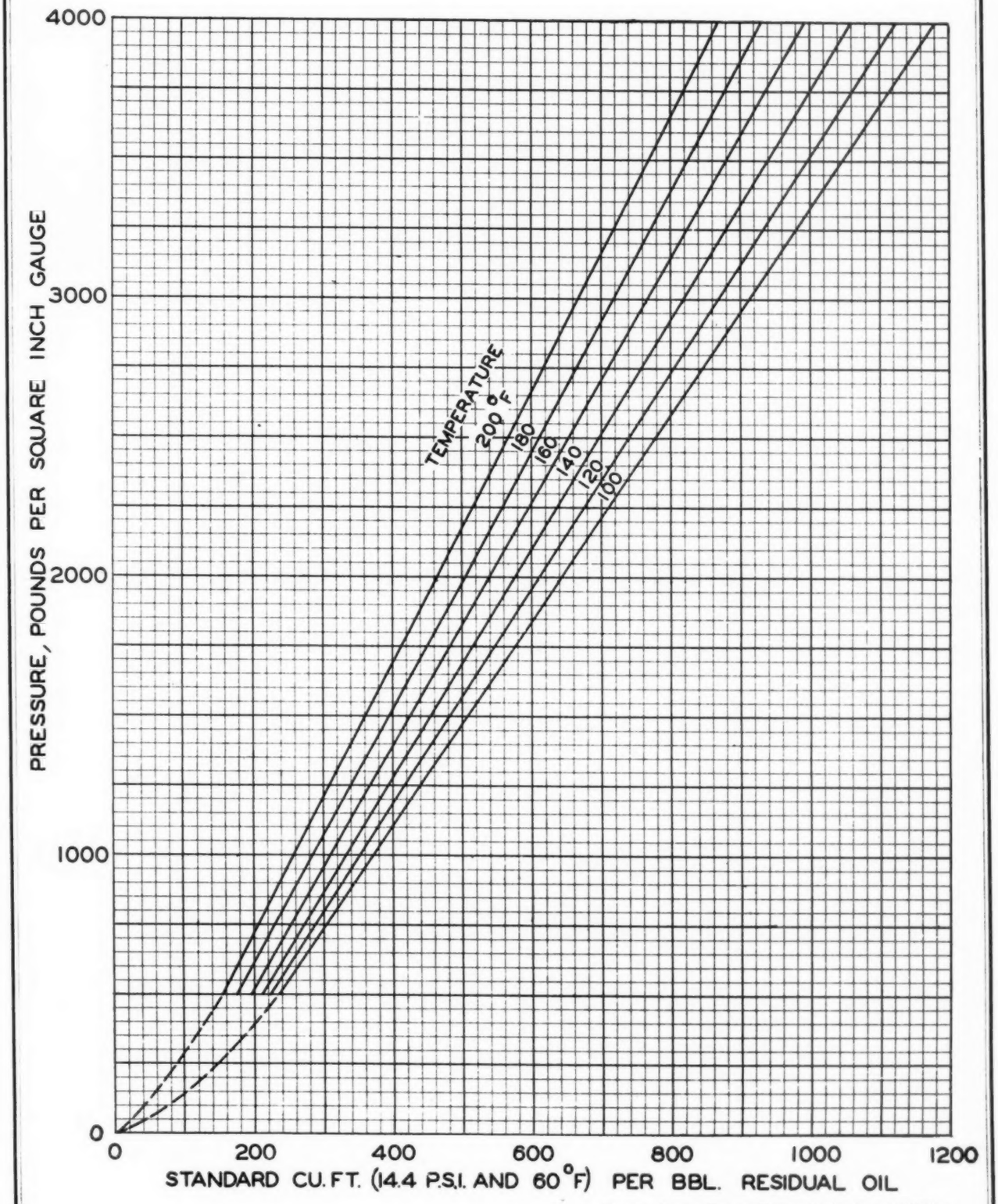
It's a quick-reference manual... sort of a "scrap book" collection of fundamental engineering data such as you might assemble yourself, from various sources, to obviate the necessity of poring through numerous books to find certain formulae or data.

In addition, it contains much new material which eliminates lengthy calculations. For example, in the 10-page section on Press Fits, charts are used to determine the expansion and contraction of compound cylinders and the radial pressure existing between them. Desired information can be read directly from the charts.

A limited edition of this new 96-page Roller Bearing Engineering Handbook is now being distributed to leading engineers and designers throughout the country. A request on your company letterhead, stating your position, will bring you a copy with our compliments. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey

HYATT ROLLER BEARINGS

SOLUBILITY OF NATURAL GAS IN CRUDE OIL

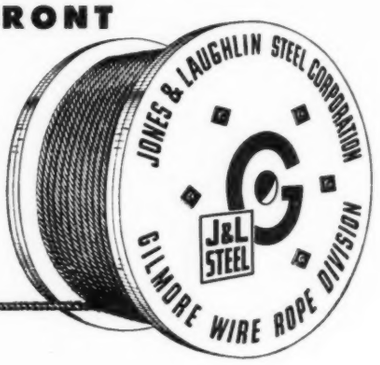


—Chart by George Granger Brown, University of Michigan.

WIRE ROPE IS THE LIFELINE

FROM PRODUCTION FRONT TO BATTLE-FRONT

Keep your wire rope doing its duty for the duration



Wire rope is as vital to winning this war . . . as are guns and ships and planes. For none of these fighting tools could be made or shipped or put into action so quickly without wire rope. Wire rope reaches back to the source of raw materials . . . hoists, pulls, moves them into production . . . swings the finished matériel on to ships . . . unloads it . . . puts it on the fighting line.

As a user of wire rope you can do your part by making every length of rope last and last. And this you can do by care . . . extra care . . . unceasing care. Your regular source of supply is ready to give you helpful information on how to get maximum ton-miles of service from your wire rope.

HOW TO MAKE YOUR WIRE ROPE LAST LONGER

Select the right rope for the job

1. Get the proper construction
2. Be sure the size is right
3. Specify the right lay
4. Allow ample safety factor

Install wire rope properly

1. Unreel rope correctly
2. Wind rope on drum properly
3. Do not allow rope to kink
4. Fix adequate clamps properly
5. Reeve rope through sheaves and blocks carefully
6. Seize rope-ends thoroughly

Be diligent in maintenance of wire rope

1. Inspect ropes regularly and carefully
2. Inspect sheaves and bearings often and thoroughly
3. Check rope lubricant frequently
4. Clean ropes regularly
5. Avoid impact or shock loads

JONES & LAUGHLIN STEEL CORPORATION

WIRE ROPE DIVISION

PITTSBURGH AND MUNCY, PENNSYLVANIA

J&L STEEL

CHART FOR DETERMINING THE VALUE OF "F" FOR USE IN THE FORMULA $P = 0.000193\ FQ^2S$ FOR OIL FLOW IN 8-IN. PIPE

Formula:

$$X = 22.12\,\frac{Q/D}{\mu/S}$$

Where:

X = criterion,
Q = discharge, bbl. per hr.,
D = inside diameter of pipe, in.,
μ = abs. viscosity in poises, and
S = sp. gr.
$= \dfrac{141.5}{131.5 + °\text{A.P.I.}}$

Example:

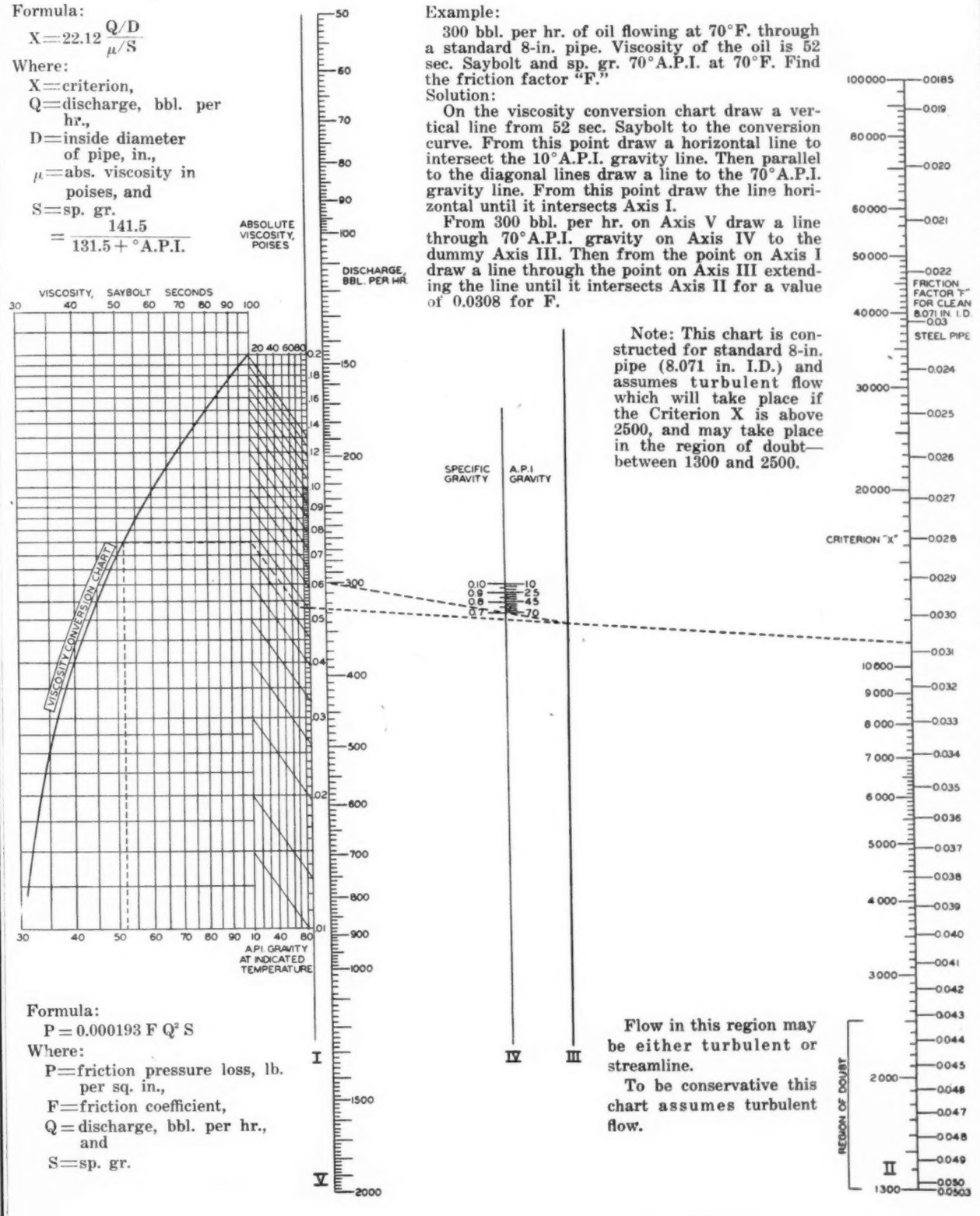
300 bbl. per hr. of oil flowing at 70°F. through a standard 8-in. pipe. Viscosity of the oil is 52 sec. Saybolt and sp. gr. 70°A.P.I. at 70°F. Find the friction factor "F."

Solution:

On the viscosity conversion chart draw a vertical line from 52 sec. Saybolt to the conversion curve. From this point draw a horizontal line to intersect the 10°A.P.I. gravity line. Then parallel to the diagonal lines draw a line to the 70°A.P.I. gravity line. From this point draw the line horizontal until it intersects Axis I.

From 300 bbl. per hr. on Axis V draw a line through 70°A.P.I. gravity on Axis IV to the dummy Axis III. Then from the point on Axis I draw a line through the point on Axis III extending the line until it intersects Axis II for a value of 0.0308 for F.

Note: This chart is constructed for standard 8-in. pipe (8.071 in. I.D.) and assumes turbulent flow which will take place if the Criterion X is above 2500, and may take place in the region of doubt—between 1300 and 2500.



Formula:

$$P = 0.000193\ F\ Q^2\ S$$

Where:

P = friction pressure loss, lb. per sq. in.,
F = friction coefficient,
Q = discharge, bbl. per hr., and
S = sp. gr.

Flow in this region may be either turbulent or streamline.

To be conservative this chart assumes turbulent flow.

ACTION SHOTS OF PIPE LINES THAT WILL DEFY RUST!

ALL of these pipe lines and service lines have been protected against corrosion with NO-OX-ID and NO-OX-IDized Wrapper. The pipe is coated with NO-OX-ID which is double acting . . . mechanically by excluding moisture and oxygen and chemically by inhibiting any underfilm corrosion which may be present.

NO-OX-IDized Wrapper completes the water vapor barrier and provides high dielectric protection. Both are applied simultaneously by stationary machine, traveling machine, or by hand. Write for complete information.

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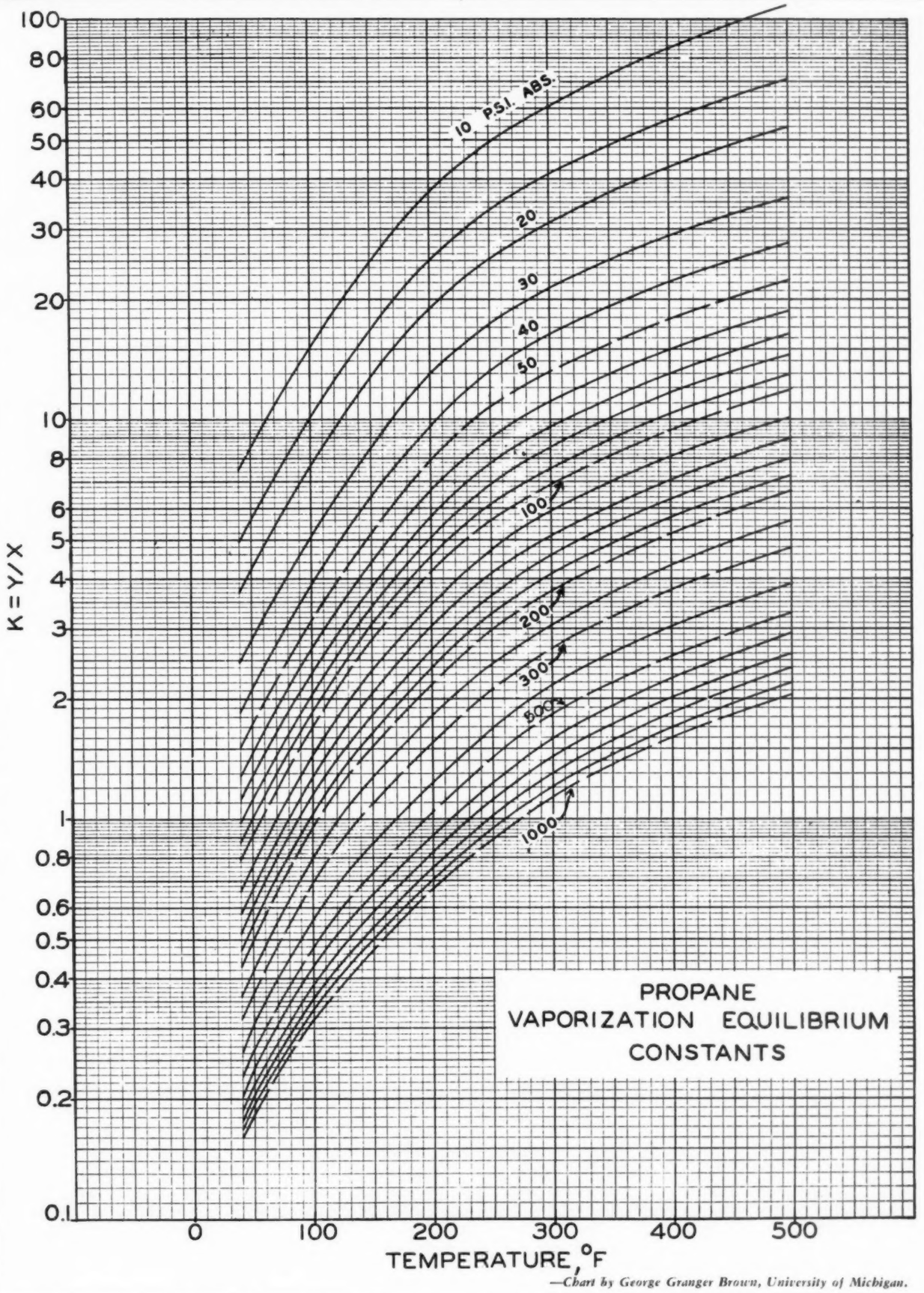
"THE LEADER FOR 25 YEARS"

NO-OX-ID
IRON + OX = RUST
rust preventive

VAPORIZATION EQUILIBRIUM CONSTANTS FOR PROPANE



—Chart by George Granger Brown, University of Michigan.

of Course **PAGE**

MAKES ELECTRODES FOR WELDING ARMOR

PHOTO BY OFFICE OF WAR INFORMATION

When it was just beginning to be understood that adopting a welded construction could multiply America's tank output, **PAGE** developed its own electrode for welding Armor—just as **PAGE** also developed its range of electrodes for welding Stainless Steel, when little Stainless was being welded.

Only one electrode is necessary to weld Armor. But **PAGE**—in conjunction with America's largest producer of Stainless Steel—developed such a wide range of **PAGE** Allegheny **ELECTRODES** that from it the welder can choose the electrode that will deposit metal in the weld that equals whatever Stainless Steel he may be welding.

As you use electrodes in these days of scarcity, we continue to caution that these should be used carefully. Use electrodes of correct analysis and of most economical diameter. Encourage welders to deposit no extra metal in the weld and to use their electrodes right to the holder.

PAGE

WELDING ELECTRODES

PAGE STEEL AND WIRE DIVISION

Monessen, Pa., Atlanta, Chicago, New York, Pittsburgh, San Francisco, Portland

AMERICAN CHAIN & CABLE COMPANY, Inc.

BRIDGEPORT • CONNECTICUT

ESSENTIAL PRODUCTS . . . TRU-LAY Aircraft, Automotive, and Industrial Controls, TRU-LOC Aircraft Terminals, AMERICAN CABLE Wire Rope, TRU-STOP Brakes, AMERICAN Chain, WEED Tire Chains, ACCO Malleable Castings, CAMPBELL Cutting Machines, FORD Hoists, Trolleys, HAZARD Wire Rope, Yacht Rigging, MANLEY Auto Service Equipment, OWEN Springs, PAGE Fence, Shaped Wire, Welding Wire, READING-PRATT & CADY Valves, READING Electric Steel Castings, WRIGHT Hoists, Cranes, Presses . . . *In Business for Your Safety*

ONE HOUR COEFFICIENT AT VARIOUS PRESSURE BASES, 4.026 I.D. PIPE
(Flange Connections)

Plate size, in.	13.0 lb. per sq. in. plus					13.5 lb. per sq. in. plus				
	4 oz.	8 oz.	10 oz.	1 lb.	2 lb.	4 oz.	8 oz.	10 oz.	1 lb.	2 lb.
	1.1057	1.0852	1.0752	1.0464	0.9767	1.0655	1.0464	1.0372	1.0104	0.9452
4x 1/4	18.4	18.0	17.8	17.4	16.2	17.7	17.4	17.2	16.8	15.7
4x 3/8	41.4	40.6	40.2	39.1	36.5	39.8	39.1	38.8	37.8	35.4
4x 1/2	73.5	72.2	71.5	69.6	65.0	70.9	69.6	69.0	67.2	62.9
4x 5/8	114.9	112.8	111.7	108.7	101.5	110.7	108.7	107.8	105.0	98.2
4x 3/4	165.4	162.3	160.8	156.5	146.1	159.4	156.5	155.2	151.2	141.4
4x 7/8	225.1	220.9	218.9	213.0	198.9	216.9	213.0	211.2	205.7	192.4
4x1	294.0	288.6	285.9	278.2	259.7	283.3	278.2	275.8	268.7	251.3
4x1 1/8	372.1	365.2	361.8	352.1	328.7	358.5	352.1	349.0	340.0	318.1
4x1 1/4	459.4	450.9	446.7	434.8	405.8	442.7	434.8	431.0	419.8	392.7
4x1 3/8	555.8	545.5	540.5	526.0	491.0	535.6	526.0	521.4	507.9	475.2
4x1 1/2	661.4	649.2	643.2	626.0	584.3	637.4	626.0	620.5	604.4	565.4
4x1 5/8	776.3	761.9	754.9	734.7	685.7	748.1	734.7	728.2	709.4	663.6
4x1 3/4	901.5	884.8	876.6	853.1	796.3	868.7	853.1	845.6	823.8	770.6
4x1 7/8	1040.2	1021.0	1011.5	984.5	918.9	1002.4	984.5	975.8	950.6	889.2
4x2	1194.3	1172.1	1161.3	1130.2	1054.9	1150.8	1130.2	1120.3	1091.3	1020.9
4x2 1/8	1365.5	1340.2	1327.9	1292.3	1206.2	1315.9	1292.3	1280.9	1247.8	1167.3
4x2 1/4	1556.4	1527.5	1513.5	1472.9	1374.8	1499.8	1472.9	1460.0	1422.2	1330.5
4x2 3/8	1769.0	1736.2	1720.2	1674.1	1562.6	1704.7	1674.1	1659.4	1616.5	1512.2
4x2 1/2	2006.2	1969.0	1950.8	1898.6	1772.1	1933.2	1898.6	1881.9	1833.3	1715.0
4x2 3/4	2565.2	2517.7	2494.5	2427.6	2265.9	2472.0	2427.6	2406.3	2344.1	2192.9

Plate size, in.	13.9 lb. per sq. in. plus					14.4 lb. per sq. in. plus				
	4 oz.	8 oz.	10 oz.	1 lb.	2 lb.	4 oz.	8 oz.	10 oz.	1 lb.	2 lb.
	1.0353	1.0174	1.0086	0.9832	0.9214	1.0000	0.9832	0.9750	0.9513	0.8932
4x 1/4	17.2	16.9	16.7	16.3	15.3	16.6	16.3	16.2	15.8	14.8
4x 3/8	38.7	38.1	37.7	36.8	34.5	37.4	36.8	36.5	35.6	33.4
4x 1/2	68.8	67.7	67.1	65.4	61.3	66.5	65.4	64.8	63.3	59.4
4x 5/8	107.6	105.7	104.8	102.2	95.7	103.9	102.2	101.3	98.8	92.8
4x 3/4	154.9	152.2	150.9	147.1	137.8	149.6	147.1	145.9	142.3	133.6
4x 7/8	210.8	207.1	205.4	200.2	187.6	203.6	200.2	198.5	193.7	181.9
4x1	275.3	270.5	268.2	261.4	245.0	265.9	261.4	259.3	253.0	237.5
4x1 1/8	348.4	342.4	339.4	330.8	310.1	336.5	330.8	328.1	320.1	300.6
4x1 1/4	430.2	422.7	419.1	408.5	382.8	415.5	408.5	405.1	395.3	371.2
4x1 3/8	520.4	511.4	507.0	494.3	463.2	502.7	494.3	490.1	478.2	449.1
4x1 1/2	619.3	608.6	603.3	588.2	551.2	598.2	588.2	583.2	569.1	534.4
4x1 5/8	726.9	714.3	708.1	690.3	646.9	702.1	690.3	684.5	667.9	627.2
4x1 3/4	844.1	829.5	822.3	801.6	751.2	815.3	801.6	794.9	775.6	728.3
4x1 7/8	974.0	957.2	948.9	925.0	866.9	940.8	925.0	917.3	895.0	840.4
4x2	1118.2	1098.9	1089.4	1062.0	995.2	1080.1	1062.0	1053.1	1027.5	964.9
4x2 1/8	1278.6	1256.5	1245.6	1214.3	1137.9	1235.0	1214.3	1204.1	1174.9	1103.2
4x2 1/4	1457.3	1432.1	1419.7	1384.0	1297.0	1407.6	1384.0	1372.4	1339.0	1257.4
4x2 3/8	1666.4	1627.7	1613.7	1573.0	1474.1	1599.9	1573.0	1559.9	1522.0	1429.2
4x2 1/2	1878.4	1846.0	1830.0	1783.9	1671.8	1814.4	1783.9	1769.0	1726.0	1620.8
4x2 3/4	2401.9	2360.4	2340.0	2281.0	2137.6	2320.0	2281.0	2262.0	2207.0	2072.5

Plate size, in.	14.7 lb. per sq. in. plus				
	4 oz.	8 oz.	10 oz.	1 lb.	2 lb.
	0.9799	0.9638	0.9560	0.9331	0.8772
4x 1/4	16.3	16.0	15.9	15.5	14.6
4x 3/8	36.6	36.0	35.8	34.9	32.8
4x 1/2	65.2	64.1	63.6	62.1	58.3
4x 5/8	101.8	100.1	99.3	96.9	91.1
4x 3/4	146.6	144.2	143.0	139.6	131.2
4x 7/8	199.5	196.2	194.6	190.0	178.6
4x1	260.6	256.3	254.2	248.1	233.2
4x1 1/8	329.7	324.3	321.7	314.0	295.2
4x1 1/4	407.1	400.5	397.2	387.7	364.5
4x1 3/8	492.6	484.5	480.6	469.1	441.0
4x1 1/2	586.2	576.5	571.9	558.2	524.7
4x1 5/8	688.0	676.7	671.2	655.1	615.9
4x1 3/4	798.9	785.8	779.4	760.8	715.2
4x1 7/8	921.9	906.7	899.4	877.9	825.3
4x2	1058.4	1041.0	1032.6	1007.8	947.5
4x2 1/8	1210.2	1190.3	1180.7	1152.4	1083.3
4x2 1/4	1379.3	1356.6	1345.7	1313.4	1234.7
4x2 3/8	1567.7	1542.0	1529.5	1492.9	1403.4
4x2 1/2	1777.9	1748.7	1734.6	1693.0	1591.6
4x2 3/4	2273.4	2236.0	2217.9	2164.8	2035.1

The above table of orifice plate coefficients, for 4.026 I.D. pipe, flange connections for various plate sizes has a pressure base of 14.4 lb. per sq. in. plus 4 oz., 0.60 gravity, and 60°F.

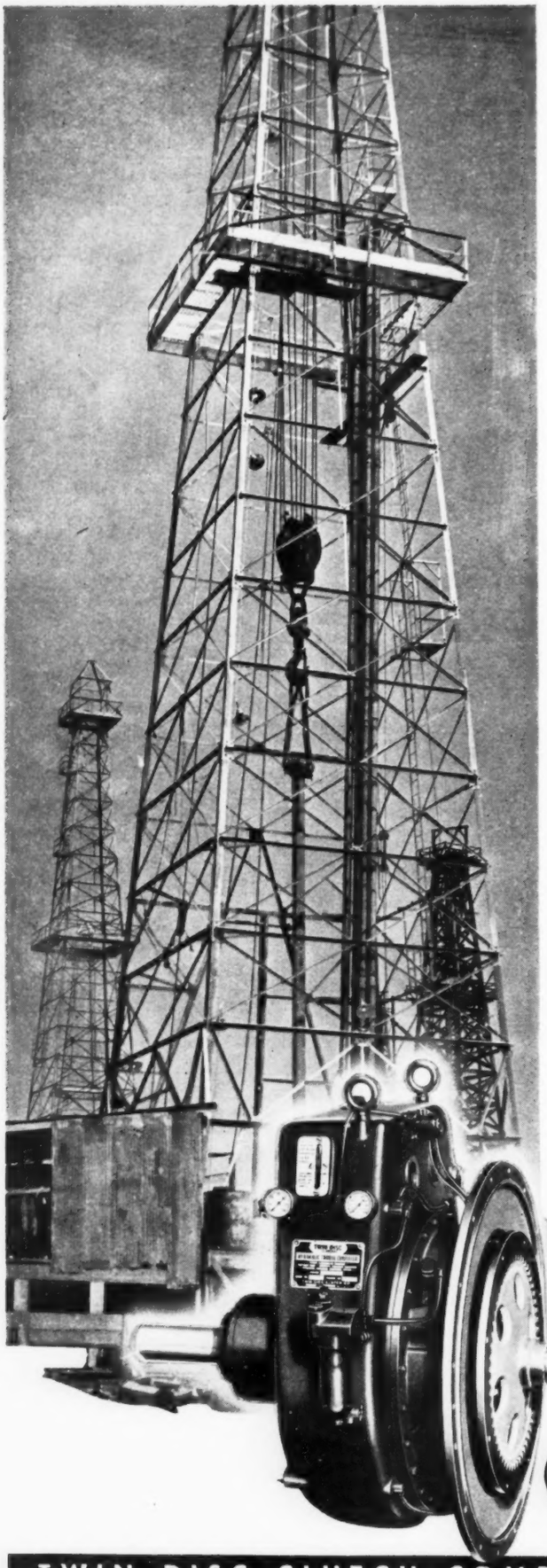
Formula: $C = C' \times D^2 \times$ P.B.G.T. factor

where: $C = \frac{d}{D}$ and d = orifice plate size, D = pipe diameter

Example: To change from one pressure base to another the multiplier = present pressure base/proposed pressure base. In changing 14.4 lb. plus 4 oz. to 13.0 lb. plus 4 oz., multiplier = 1.1057.

4×1 orifice plate at 14.4 lb. plus 4 oz.

$= 265.9 \times \sqrt{h(14.4+P)} =$ M. cu. ft. per hr.



Top Speed for "Coming out"

With a Twin Disc Hydraulic Torque Converter, you can "come out of the hole FAST" . . . save valuable time. No need to nurse your engine along while it picks up speed . . . not even a sudden, shock load can stall it because the converter cushions the shock . . . automatically adjusts speed to load.

Equipped with a torque converter, your gas or diesel engine will work at its best . . . give you "full head of steam" performance at all times . . . because the torque converter provides high torque at low output shaft speeds.

Both the Twin Disc Hydraulic Torque Converter and the Twin Disc Hydraulic Coupling will dampen out the engine's cyclic variations . . . increase the life of your transmission . . . but *only* the Hydraulic Torque Converter will give you the added advantage of torque multiplication.

Inquiries from rig builders with revolutionary ideas about "Draw-works of the Future" will be welcomed by the Engineering Department, Hydraulic Division, Twin Disc Clutch Company, Rockford, Illinois.

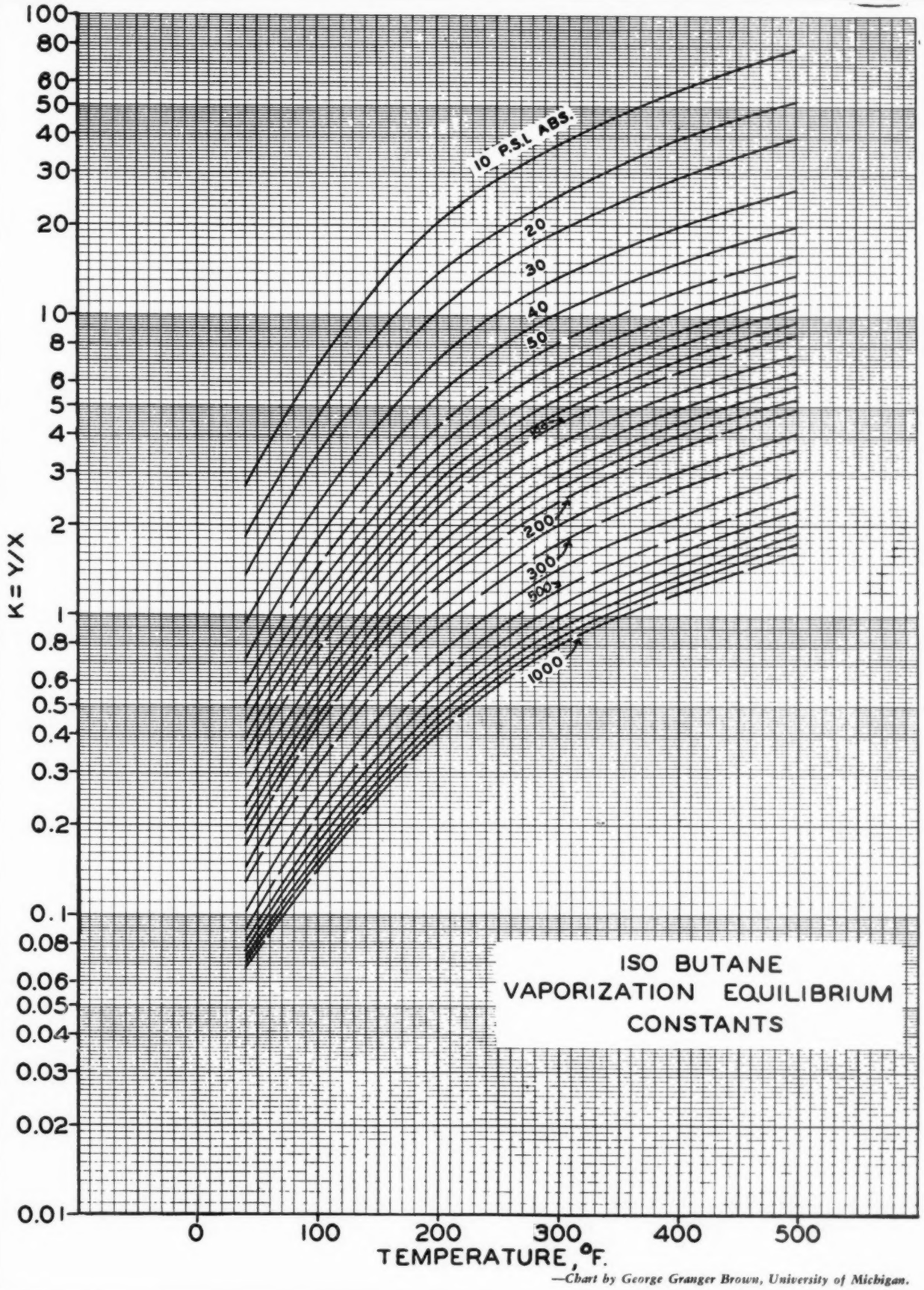
Left: Twin Disc Hydraulic Torque Converter (Lysholm-Smith type). In considering installation, ask for complete data and specific recommendations.

Right: Twin Disc Hydraulic Power Take-off for application to internal combustion engines with standard S.A.E. flywheel housing dimension. Sizes: 14" to 24". In considering installation, ask for complete data and specific recommendations.

TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES
REG. U.S. PAT. OFF.

TWIN DISC CLUTCH COMPANY • RACINE, WISCONSIN

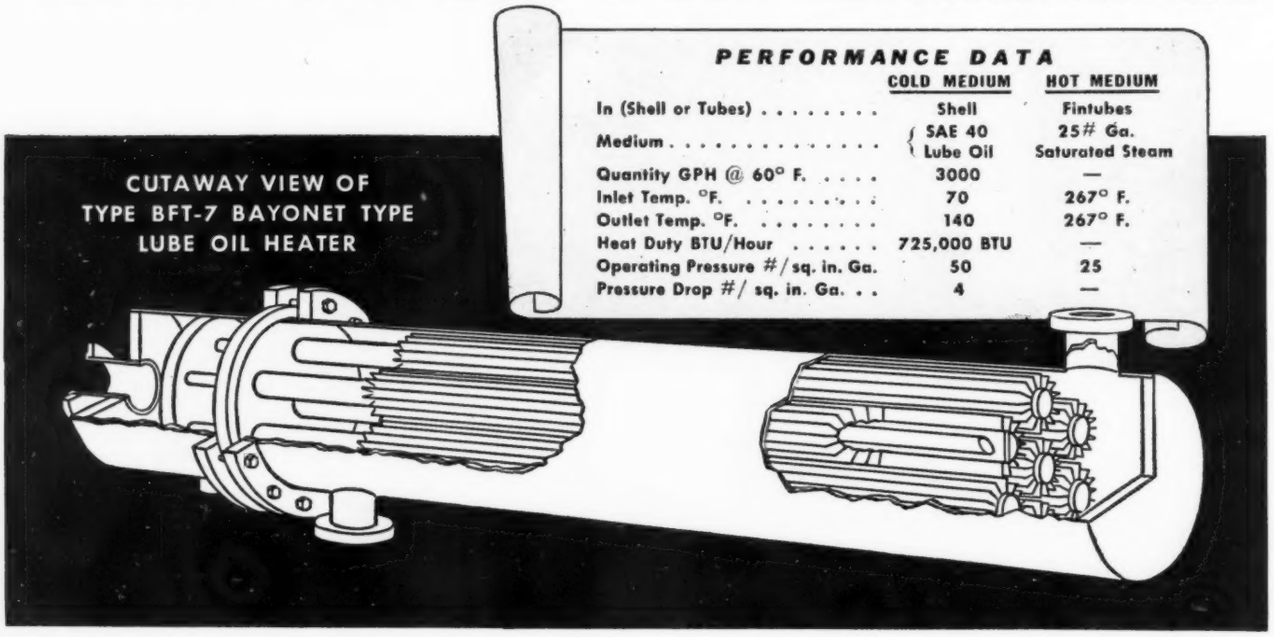
VAPORIZATION EQUILIBRIUM CONSTANTS FOR *ISO*BUTANE



—*Chart by George Granger Brown, University of Michigan.*

GET GREATER CAPACITY WITH SMALLER SHELLS... LESS WEIGHT... AND LESS PRESSURE DROP WITH

BROWN FINTUBE HEAT EXCHANGERS


PERFORMANCE DATA
COLD MEDIUM
HOT MEDIUM
In (Shell or Tubes) . . . . . Shell Fintubes
Medium . . . . . SAE 40 Lube Oil 25# Ga. Saturated Steam
Quantity GPH @ 60° F. . . . . 3000 —
Inlet Temp. °F. . . . . 70 267° F.
Outlet Temp. °F. . . . . 140 267° F.
Heat Duty BTU/Hour . . . . . 725,000 BTU —
Operating Pressure #/sq. in. Ga. 50 25
Pressure Drop #/ sq. in. Ga. . . 4 —
CUTAWAY VIEW OF TYPE BFT-7 BAYONET TYPE LUBE OIL HEATER

9" x 14'3" Overall, Type BFT-7 Bayonet Type Lube Oil Heater, provides 300 sq. ft. of Effective Surface— Transfers 725,000 BTU per Hour

● Because Brown integrally bonded Fintubes having the desired number and depth of fins, are used in effecting the heat transfer,—the primary and secondary tube surfaces of Brown Fintube Heat Exchangers can be proportioned to the transfer co-efficients of the materials being heated or cooled, thereby compensating for any deficiency in the heat transfer rate of one or another of the commodities.

This avoids the necessity of using hundreds, sometimes thousands of feet of bare tubing to satisfy the requirement of the commodity having the lower heat transfer co-efficient. It permits a fewer number, or shorter, Brown Fintubes to be used for a given heat transfer service than if plain bare tubes were used . . . and results in many important savings in manufacturing, shipping, installation and maintenance costs.

Brown Integrally Bonded Fintubes are used in all Brown Fintube Heat Exchangers—in exchangers made by most other manufacturers—and are available in a wide variety of sizes, and in mild carbon or special steels, for practically any heating or cooling requirement.

Six standard and many special types of Brown Fintube Heat Exchangers meet every requirement for effecting transfers between liquids and gases, and other commodities having unequal heat transfer co-efficients,—and provide the high thermal efficiency and trouble-free operation that only Brown resistance-welded integrally-bonded Fintubes can give you.

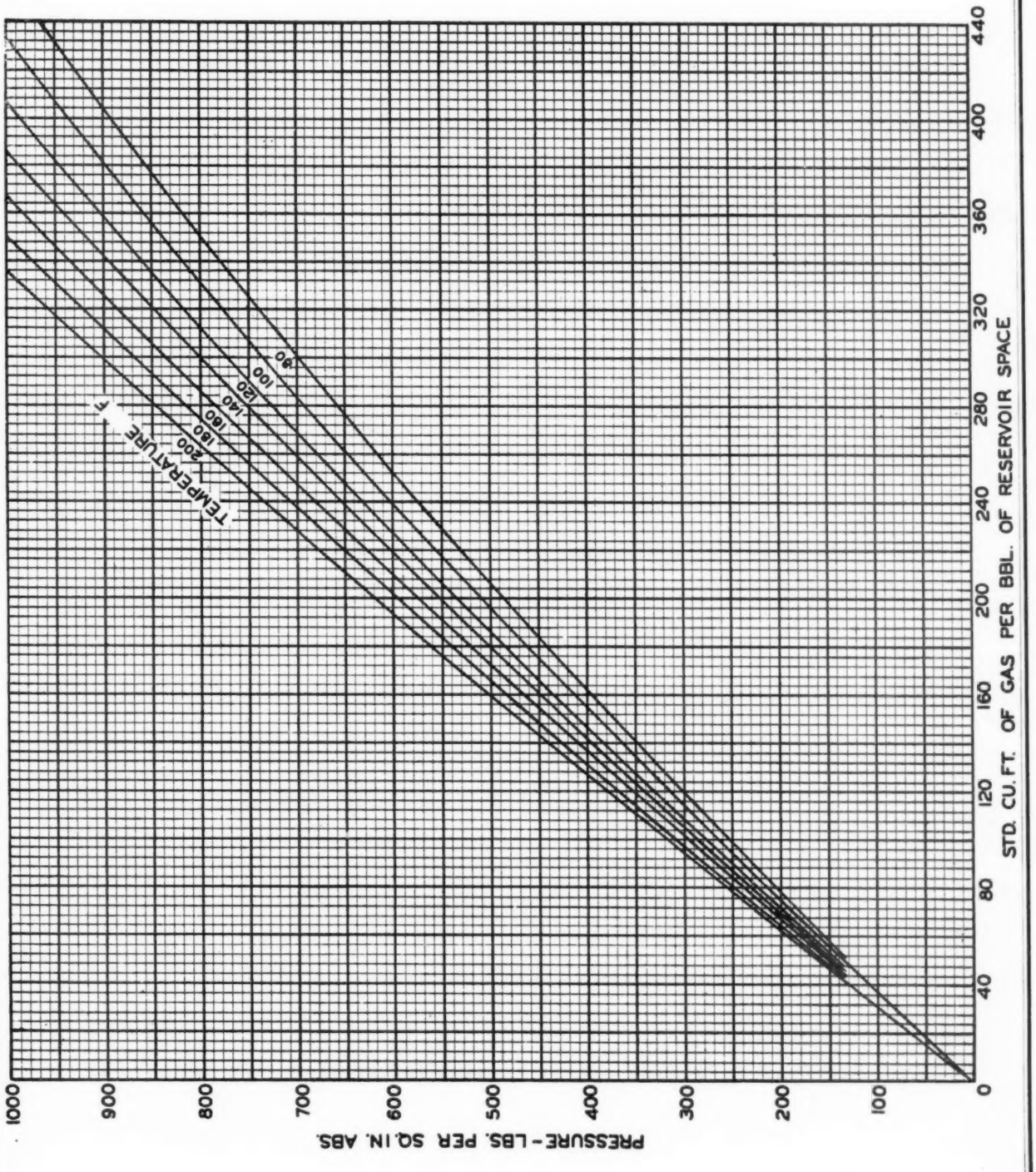
More complete details and fully descriptive literature furnished gladly. Let us quote on your heat exchanger requirements.

THE BROWN FINTUBE CO.

125 FILBERT STREET • ELYRIA, OHIO

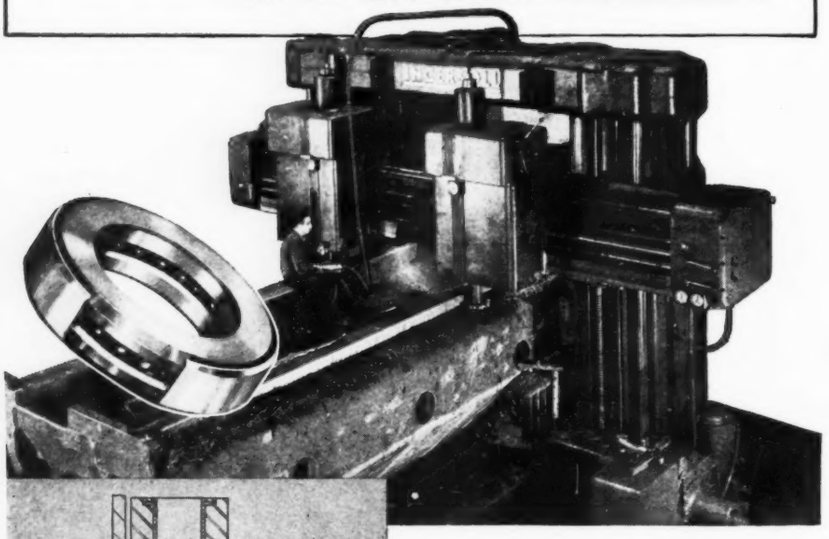
MANUFACTURERS OF INTEGRALLY BONDED FINTUBES AND FINTUBE HEAT EXCHANGERS

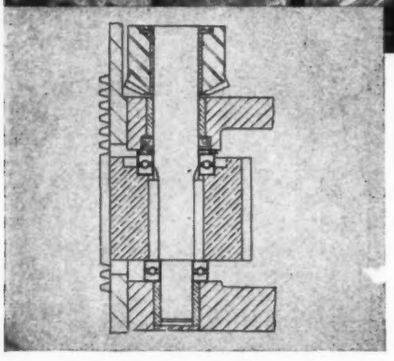
STANDARD CU. FT. OF GAS PER UNIT VOLUME OF RESERVOIR SPACE



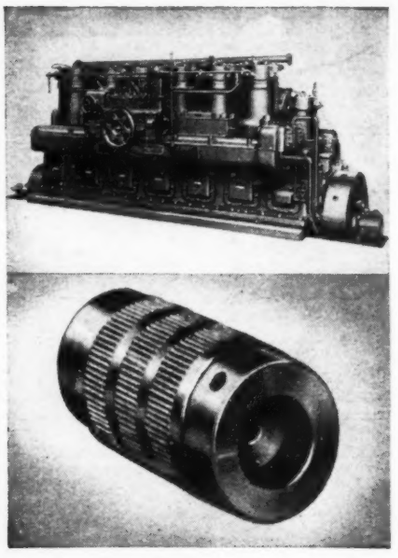
—*Chart by George Granger Brown, University of Michigan*

IN THE NEWS
WITH BANTAM BEARINGS

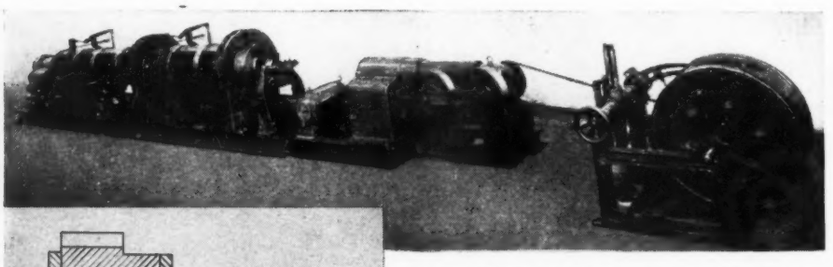


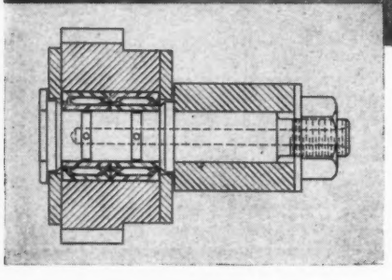


GIANT AMONG MACHINE TOOLS is this 180-ton model built by The Ingersoll Milling Machine Company and shown here at work milling a 25-ton casting. In the four cutting heads of this unit—designed so any two can simultaneously utilize the full 100 h.p. of the drive motor—power transmission is assured by the use of Bantam Ball Thrust Bearings as shown in the accompanying cross-section. This application is an interesting example of Bantam's proven ability to supply bearings for unusual and difficult service requirements.



PROVIDING PRIMARY POWER with absolute dependability is the job of this Fairbanks, Morse Diesel Engine. To achieve the high load capacity and long service life required of the piston pin bearings in such machines, special wrist-pin needle bearings designed and built by Bantam are employed. Bantam has long pioneered in the design and manufacture of special bearings for unusual applications.





ENDLESS MILES OF WIRE are stranded with this machine built by The New England Butt Company. And contributing to its efficient design and operation are Bantam Quill Bearings used in the idler gears of the wind-up reels. Bantam's Quill Bearings combine the important advantage of high load capacity in compact design with ease of installation and unusually efficient lubrication.

NEEDLE ROLLER BEARINGS provide the high unit capacity to insure lasting, maintenance-free operation of the bull pinion and differential side gear on the differential shaft in Oliver Farm Equipment Company's Row Crop 70 Tractors. This is a typical application where an assembly of Bantam Needle Rollers can be utilized to advantage to provide anti-friction operation within minimum space requirements.

A COMPLETE NEEDLE BEARING SERVICE is offered by the combined facilities of Torrington and Bantam. Here, from a single source, you can get the unbiased counsel of engineers experienced in the selection and design of bearings for every purpose. Bantam also offers aid in designing bearings for special requirements as well as a dependable source for every major type of anti-friction bearing—straight roller, tapered roller, needle and ball. To meet today's urgent demands or in planning for post-war needs, TURN TO BANTAM for the prompt solution of your bearing problems.

ARMY (E) NAVY

BANTAM BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

THE TORRINGTON COMPANY · BANTAM BEARINGS DIVISION

SOUTH BEND, INDIANA

Army Calls on Oil Industry For Scrap

"OIL companies are believed to be a veritable storehouse of scrap metal, asserts Major Alfred R. Teter, coördinator of salvage of the Eighth Service Command, "and with the acute shortage of scrap in the steel mills today, the coöperation of the industry is needed to aid the Army in its scrap collection activities."

The office of coördinator of salvage was created by Major General Richard Donovan, commanding general of the Eighth Service Command, whose headquarters are at Dallas, Texas, to coördinate and facilitate all scrap metal operations between military and civilian authorities. Under the direction of this office the first unit of its kind in the United States has been formed. It is a mobile salvage collecting company, fully trained in the collection, segregation, and removal of scrap and completely equipped with trucks, cranes, oxy-acetylene torches, motorized winches, block and tackles, air compressors for dismantling large pieces, and other cutting implements. This company is now actively participating in scrap collections throughout the command.

Information recently received from Washington indicates that there is on hand only a 45-day inventory of scrap metal in the mills. With our plants being required to produce more than 100,000,000 tons of finished steel this year, four times the peace time tonnage, and in so doing doubling the combined output of the enemy nations, scrap metal collections must be intensified. The Army is using every facility at its disposal to assist the mills in obtaining an ample supply or reservoir of scrap, for the plants consume over 150,000 tons of scrap metal daily.

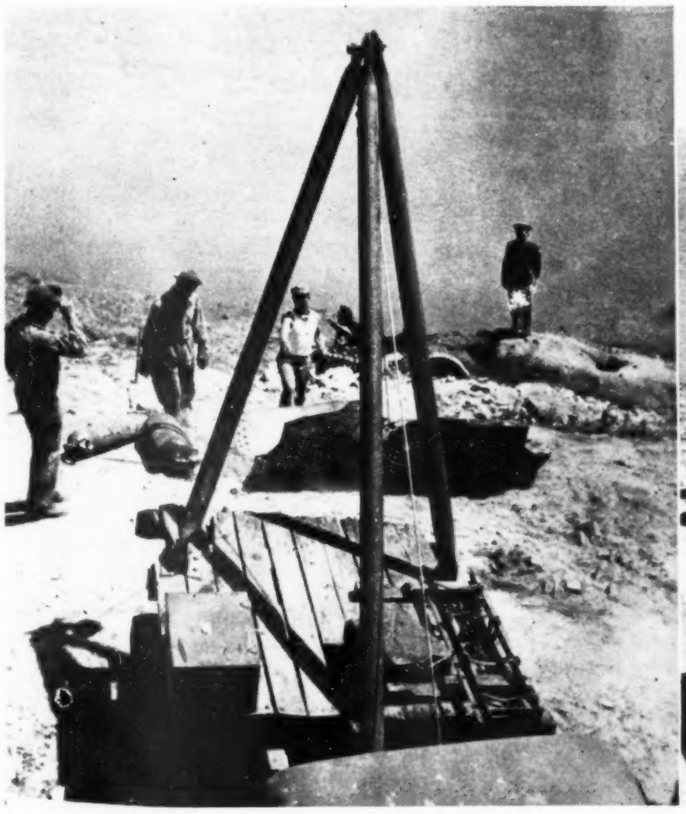
The Army needs every last ounce of scrap it can get and is particularly seeking the continued support of the oil industry, for the old boilers, scrap oil cables, pipe lines, and other obsolete equipment it possesses, are worthless to companies but are extremely valuable to the government.

It is believed there is still an abundance of scrap metal on the many oil leases in Texas, Arkansas, Oklahoma, Louisiana, and New Mexico, the five states of the command. A recent letter from the coördinator to oil firms requests permission for Army personnel and trucks to visit their premises and to collect such scrap metal as may be designated by their superintendents. The Army is providing the labor and transportation for those who patriotically donate their scrap to the government and will make certain that the scrap metals so obtained will be shipped to the mills for the manufacture of essential armaments. Scrap is required in this production for one-half of steel is made of scrap metal.

A recent directive from Washington reveals that the collection and salvage of scrap copper, brass, and bronze must be a major goal of the Army's scrap program also.

It is urged that those who have scrap coöperate with the Army by notifying the coördinator of salvage, Eighth Service Command, Santa Fe Building, Dallas, Texas, of the scrap iron, steel, copper, brass, and bronze on oil leases which it is desired to give to the Army to help make the equipment needed.

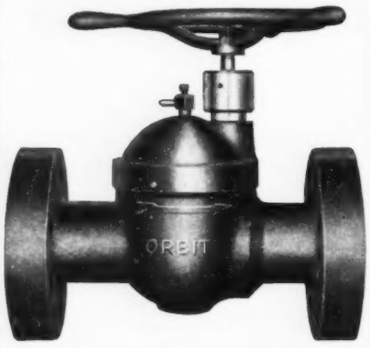
☆ ☆ ☆



Soldiers of the Eighth Service Command Salvage Collection Detachment of Fort Bliss, Texas, recovering steel boiler plate from bed of Rio Grande

From
WELL
CONTROL
To
FIRE
CONTROL

Mechanical control of the forces of nature or those of man's forces of war—is a matter of engineering training, skilled workmanship and adequate manufacturing facilities.



THE ORBIT GEARED MASTER VALVE

It is only natural that our 31 years of experience should be devoted to the War effort.

Therefore, for the duration, most of our manufacturing facilities for the manufacture of Orbit Valves have been converted to the production of vital equipment for our fighting forces.

YOUR ORBIT VALVES

Will last for the duration. Meanwhile, if you have any questions regarding their care and maintenance, write us.

OIL WELL IMPROVEMENTS CO.

TULSA, OKLAHOMA

Running Tour

WITH MEN IN THE INDUSTRY

H. L. FARRAR, president of the Coast Counties Gas and Electric Company, San Francisco, California, has been named to the board of trustees of the Institute of Gas Technology at Illinois Institute of Technology. Farrar is the only new director, other officers of the Institute being re-elected.

JACK P. HAYS, for the last six years associate professor of Petroleum Engineering at Texas A. and M. College, has resigned to go with the Seaboard Oil Company, Dallas, Texas, as petroleum engineer. Hays is a graduate of the University of California and before joining the Texas college faculty was with Shell Oil Company.

C. S. JONES, president of Richfield Oil Corporation and chairman of the Transportation Committee for District Five, has been appointed vice-chairman of the General Committee of the Petroleum Industry Committee for District Five, it was announced by WILLIAM F. HUMPHREY, chairman.

C. H. RANKIN, Electra, Texas, has resigned from the Continental Oil Company to engage in consulting work. Rankin has been with Continental 14 years, 7 years as geologist in the Rocky Mountain division and 7 years in the production department, having served as foreman and district superintendent in Oklahoma, New Mexico, Colorado, and Texas.

HAROLD B. FELL, president of the Simpson-Fell Oil Company, Ardmore, Oklahoma, was named chairman of the petroleum industry Production Committee for the Midwestern States (District Two). He succeeds Otto Donnell, now head of the general committee for this region.

Engaged in the oil industry in Oklahoma for 23 years, Fell has a degree in civil engineering from Princeton University. He is executive vice-president of the Independent Petroleum Association of America and a member of A.P.I.

GILBERT W. NOBLE has been appointed petroleum engineer for the Ohio Oil Company at the Findlay, Ohio, office. Noble has for several years been a professor on the faculty of School of Mines and Metallurgy, University of Missouri, Rolla, Missouri.

FRED F. HUBLER, associated with Petroleum Rectifying Company, Tretolite Company, and the Dehydro Company as advertising manager, was inducted into the Army last month. He was assigned to the 940th Engineering Aviation Camouflage Battalion.

L. W. LONG has been promoted by the Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin, to the position of sales engineer in charge of mixed apparatus sales. The object of the new post is to coördinate sales involving the apparatus of more than one division of the company's electrical department. An electrical engineer graduate from Penn State University, Long went with Allis-Chalmers in 1925.

DR. FOOTE

DR. PAUL D. FOOTE, executive vice-president of the Gulf Oil Corporation's research and development organization, Pittsburgh, Pennsylvania, has been elected a member of the National Academy of Sciences. The Academy makes an annual selection of the country's leading scientists to membership.

Doctor Foote is a former president of the American Physical Society, a former vice-president of Washington Academy of Science, and is the author of numerous publications. Inventor of many instruments and methods in industrial use, Doctor Foote has been in his present position since 1927.

M. J. DELANEY, 78, independent oil operator and drilling contractor, died recently at his home in Dallas, Texas. Although never affiliated with any major oil company, Delaney was widely known for his own operations. He was a member of the Dallas Petroleum Club and had served as president of the American Association of Oilwell Drilling Contractors.

JOSEPH R. CLAIR, who joined the Skelly Oil Company June 1, is the author of "Oil and Gas Resources of Cass and Jackson Counties, Missouri," a publication just released by the Missouri State Geological Survey.

R. S. WARREN, who joined The Cooper-Bessemer Corporation eight months ago as assistant advertising manager, has been promoted to the position of sales promotion manager. Before joining his present firm, Warren was in charge of advertising and sales promotion for Invincible Manufacturing Company of Dover, Ohio. His new duties will include acting as chairman of the Labor-Management Publicity Sub-Committee where he can aid in Cooper-Bessemer's production drive.

V. H. PETERSON

V. H. PETERSON, for the last two years vice-president of the Elliott Company, has been named assistant to the president of The Baldwin Locomotive Works. Peterson began his business career with the Scovill Manufacturing Company in Waterbury, Connecticut, at the same time continuing his education in a school conducted by the city's industries. He won a scholarship to Rensselaer Polytechnic Institute from which he received a mechanical engineering degree in 1925. He entered the employ of Elliott Company where he remained until the new appointment.

JOHN H. BAIRD and I. FRANK BROWN, export representatives, were elected chairman of the board and secretary, respectively, of the Nomads. The eight members of the Board of Regents made the choice.

A. M. BUTCHER, formerly with Happy Belting Company, Tulsa, Oklahoma, has been appointed chief engineer of the Power Machinery Company, Tulsa, a distributing organization.

LARRY KING has been placed in charge of the Kansas division of the Baroid Sales Division of National Lead Company. Well known in oil circles, King will handle his territory from the Great Bend, Kansas, office.

JOSEPH C. TREES, 73, died May 19 of a heart attack in his offices in Pittsburgh, Pennsylvania. He was the partner of Michael L. Benedum and the two were among the world's best known oil wildcatters. Trees and Benedum began their partnership years ago in West Virginia, and their oil exploits had carried them all over the globe.

PATRICK J. NOON, executive secretary of the Bradford district, Pennsylvania Oil Producers Association, has resigned to join the Dresser Mfg. Co.

Wherever There's WAR ACTIVITY
There's a DISTRIBUTOR Serving It

The distributor is rendering an indispensable service these days. With his complete familiarity with requirements and sources of supply, he is helping hard-pressed procurement offices to obtain vitally needed equipment and supplies for the Army, Navy, Maritime Commission and Air Force... not to mention his services to the thousand-and-one other industries engaged in war work.

He's alive to the needs of the times and his wide experience qualifies him as the logical force to ferret out those needs... he's here, there and everywhere—any hour of the day or night. He knows that he justifies his existence only in the measure that he renders service.

Long ago, Lunkenheimer recognized the distributor as the most efficient and economical means of marketing its products and built up nation-wide distribution through leading supply houses. We salute these distributors for the outstanding job they are doing in helping to speed up war production.

ESTABLISHED 1862
THE LUNKENHEIMER CO.
"QUALITY"
CINCINNATI, OHIO, U. S. A.
NEW YORK CHICAGO
BOSTON PHILADELPHIA
EXPORT DEPT. 318-322 HUDSON ST., NEW YORK

LUNKENHEIMER VALVES

MACHINERY and EQUIPMENT

A-C. Welder Line

WITH a view of expanding its welding equipment service to war industries, Harnischfeger Corporation, Milwaukee, announces the addition of a complete line of industrial a-c. arc welders to its present extensive line of P&H d-c. machines. Engineered and built for industrial service, these machines are being made in seven heavy-duty and four intermittent-duty

models with a range of capacities for handling production welding under continuous operation. The new line features the recently adopted "WSR" (Welding Service Range) ratings, which show the actual minimum to maximum output of usable welding current. Specific "WSR" ratings of heavy-duty models are: 50 to 270 amp., 60 to 375, 90 to 500, 100 to 625, 125 to 750, 150 to 900, and 200 to 1200—of intermittent-duty models: 20 to 185 amp., 20 to 235, 20 to 285, and 20 to 335. Setting and control of current throughout complete welding service range involves one simple, easy-to-operate adjustment.

For complete details of these new products, address the Welder Division, Harnischfeger Corporation, Milwaukee, Wisconsin.

Thor Plastic Drill

FOURTEEN percent lighter in weight, but packing more power per pound under its "Thorite" plastic armor, a new Thor ¼-in. capacity electric drill was announced recently by Independent Pneumatic Tool Company, Chicago, Illinois.

Thor "armored in plastic" construction of the new drill, featuring double protection of the operating parts within an inner metal skeleton frame that is covered by entirely separate plastic housings, provides fast drilling because it is lighter and easier to handle, the manufacturer states.

The drill can be adapted to all types of heavy-duty production service.

The new Thor drills weigh only 3¼ lb., measure $8\frac{3}{16}$ in. in length, and are available in three speeds, the Thor U14K at 2500 r.p.m., the Thor U13K at 3750 r.p.m., and the Thor U12K at 5000 r.p.m.

Make Non-Metal Lockers

PLANT managers who are experiencing difficulty due to the extreme scarcity of metal lockers, will be interested in a recent announcement made by The Philip Carey Manufacturing Company, Cincinnati, Ohio. Newly designed, durable, highly efficient lockers are now being made with Careystone (Asbestos-Cement) Flat Sheathing. This material is said to provide an excellent substitute for metal, as it is produced by combining selected Portland cement and asbestos fibers under tremendous pressure, resulting in a stone-like substance that will not rust, rot, or corrode, and is fire and rodent proof.

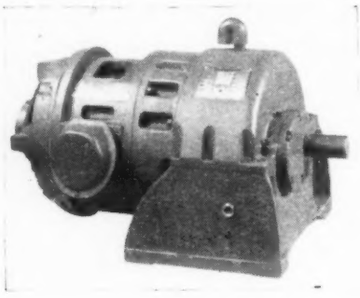
Plant carpenters or maintenance men can easily make lockers with Careystone Flat Sheathing. This material is available in sheets 48 in. by 96 in., and ⅜-in. thickness is recommended for constructing lockers.

Write The Philip Carey Manufacturing Company, Asbestos-Cement Products Department, Lockland, Cincinnati, Ohio, for details and location of nearest branch from which Careystone Flat Sheathing is available.

Line of Gearmotors

A NEW line of horizontal parallel shaft-type Gearmotors that meet speed reduction requirements for a wide variety of industrial applications over a range of 1 to 75 hp. is announced by Westinghouse Electric and Manufacturing Company. Each new unit conforms to A.G.M.A. standard output speeds and application practices.

The use of adaptor castings between motor and mechanical parts allows the use of all standard Westinghouse N.E.M.A. frame motors with each type of unit, and types of motor construction can therefore be readily changed to suit varying service conditions if necessary in the field. The design of the motor-adaptor assembly being common between unit types, such assembly can be readily shifted between unit types

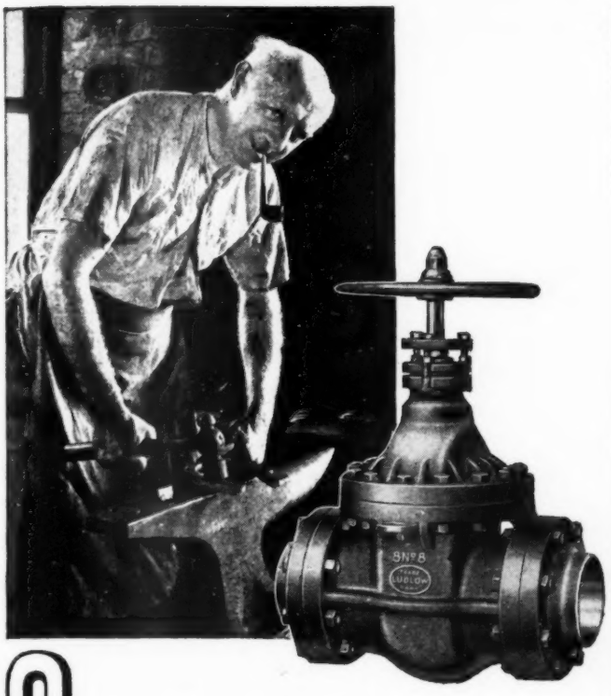


to meet changes in speed requirements. Many working parts including gear sets being common to all three unit types of a given rating, replacement part programs are held to a minimum.

Gears and pinions in the new Gearmotors are of 0.40-0.50 carbon steel, and are given special heat-treatment before hobbing. This process produces a tapering hardness from surface to core, and results in tough, impact-resisting teeth. Gears and bearings are lubricated by a positive splash system, and new case design allows oil to circulate freely at all times.

The new Gearmotors also feature compactness and improved foundation stability through heavy exterior ribbing of the housing at each mounting hole.

Further information on this complete new line of Gearmotors may be obtained from Department 7-N-20, Westinghouse Electric and Manufacturing Company, East Pittsburgh, or from the nearest Westinghouse office.



Old? Yes... and Work-Wise!

Elderly Ludlow Valves — like a work-wise veteran who has long followed his trade — are proving their worth in these days of equipment shortages. Oil men find that even grandfather-aged Ludlows have a surprising amount of active service left in their still sturdy bodies. Checked-up at the repair clinic and re-outfitted, they're going back on the job—for duration!

Now that you think of it — hasn't this more-than-average service always been a Ludlow characteristic? For these extended-service valves, Ludlow will aid in supplying the same enduring replacement parts. Check up on your priority and send in your order.

THE LUDLOW VALVE MFG. CO., INC.

TROY, NEW YORK V-14

Construction Features: Self-releasing 30° angle wedges and free-floating gates, self-adjusting to seats, afford smooth, trouble-free performance, long service. Rings are cleaned throughout stroke action. Gates are wedge-locked directly opposite ports and completely unwedged before raising. Ample tolerances provide easy action. Simple construction permits easy replacement of parts.

LUDLOW VALVES

SINCE 1866

STYRENE PRODUCTION adds to the uses of Florite

New synthetic rubber plant set in operation by The Firestone Tire and Rubber Company on Sunday, April 25. Butadiene, a by-product of gasoline refining, and styrene, a coal-tar product, are emulsified and combined to make Buna rubber. Capacity equivalent to that of 100,000 acres producing natural rubber.

THE most advanced technical processes in which desiccants and adsorbents are required, give new emphasis to the useful properties of FLORITE. Production of synthetic rubber by the styrene-butadiene process is an interesting and timely example. FLORITE has found immediate adoption and proved highly satisfactory in the great chemical plants where by "modern magic" styrene is produced.

In the drying of propane, butane, air, nitrogen, carbon dioxide, refrigeration compounds, and other fluids, FLORITE is used with marked success. Long-term effectiveness results in economy of cost. Write for data.

*Trade Mark Registered.

FLORIDIN COMPANY, INC.

ADSORBENTS

182 Liberty Street Warren, Pa.

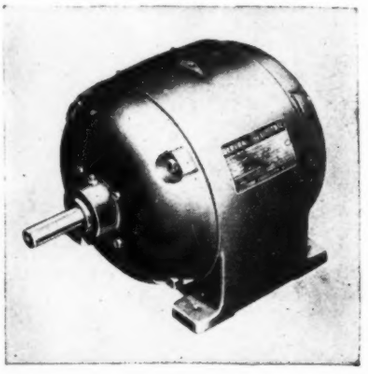
Totally Enclosed Tri-Clad Motors

A NEW line of totally enclosed motors, the most recent addition to the widely known group of Tri-Clad motors, has been announced by the Motor Division of the General Electric Company, Schenectady, New York. Available in both the polyphase, 60-cycle, induction type and the single-phase, 60-cycle, capacitor type, the new motors are especially designed for use under conditions where abrasives, chemicals, rain, snow, and excessive dirt are encountered.

The polyphase motors are supplied in frame sizes 203 to 225. They include ½, ¾, and 1 hp. at 900 r.p.m.; ¾, 1, and 1½ hp. at 1200 r.p.m.; 1, 1½, and 2 hp. at 1800 r.p.m.; and 1½ and 2 hp. at 3600 r.p.m. The single-phase motors are supplied in frame sizes 203 and 204, and include ¾ hp. at 1200 r.p.m.; 1 and 1½ hp. at 1800 r.p.m.; and 1½ and 2 hp. at 3600 r.p.m. The mounting dimensions of these motors are interchangeable with Tri-Clad open motors of the same rating.

These new motors have all the important basic features of the Tri-Clad group: protection against physical damage, electrical breakdown, and normal operating wear and tear.

In addition, all parts of the motor enclosures — frame, end shields, and conduit boxes—are cast-iron, thus of-



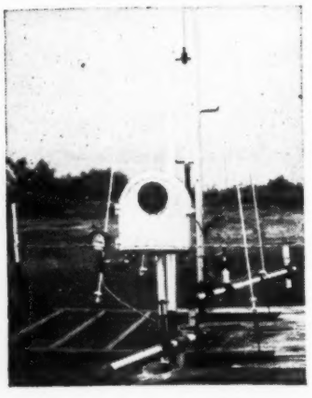
fering exceptional resistance to rust, corrosion, accidental blows, and rough use. Also, the leads are permanently encased in compound in a cast-in pocket in the stator frame, thus preventing liquids from seeping into the motor. Still further protection is provided in the form of a rotating labyrinth seal, which prevents dirt, oil, or water from entering the bearing housing.

Speeds Action of Large Diaphragm Valves

FOR better process control through faster operation of large diaphragm valve motors or of valves situated unusually long distances from controlling instruments, Taylor Instrument Companies, Rochester, New York, have announced as an addition to their line the Taylor Booster Relay Air Valve. It is

an auxiliary device that provides accelerated valve action to eliminate the effect of lag in large diaphragm motors and /or in long air lines between controlling instruments and diaphragm motors. Under these difficult conditions, the Relay Air Valve will inflate or deflate the largest Taylor Valve Motor (diaphragm of 144 sq. in.), from five to seven times faster than by controller alone.

Literature covering operating details may be obtained by writing the manufacturer for Bulletin 98090.



Install NIXON Surface Control Gas-Lift
for lower production costs.

You'll save on the original purchase price . . . you'll save on installation cost . . . you'll save on operating costs . . . you'll have very little, if any, maintenance expense.

You'll be able to produce from high or low fluid levels . . . flow large or small volumes . . . deplete the well without changing or adding to the original installation.

Nixon Gas-Lift Systems are available for immediate installation. Get all the facts about its efficient and economical operation. Write your nearest Wilson Supply Company store or sales office.

WILSON SUPPLY COMPANY
1412 MAURY STREET — HOUSTON, TEXAS

SALES OFFICES:
Tulsa, Oklahoma; Dallas, Texas
LOS ANGELES: Western Pressure Control Co., 5700 Santa Fe Avenue.
TRINIDAD, B.W.I.: Neal Massey Engineering Corporation.

BRANCH STORES:
TEXAS—Gladewater, Barbers Hill, Bay City, Monahans, Alice, Victoria, Corpus Christi.
LOUISIANA—Lake Charles, New Iberia, Harvey, Shreveport.

Special Provisions for Shallow Oil Wells

The issuance of special provisions affecting the spacing of shallow oil wells to be drilled in Eastern Kansas, Eastern and Southern Oklahoma, and North and West Central Texas, was announced May 21 by the Petroleum Administration for War in Supplementary Order No. 8 to Petroleum Administrative Order No. 11.

Under the new order, materials may be used to drill and equip oil wells in these areas under the following conditions:

1. Five-acre spacing for oil wells completed at depths not exceeding 1200 ft.
2. Ten-acre spacing for oil wells completed at depths between 1200 and 2000 ft.
3. Twenty-acre spacing for oil wells completed at depths between 2000 and 3000 ft.
4. Forty-acre spacing for oil wells completed at depths greater than 3000 ft.
5. Pumping or artificial lift equipment may be installed on oil wells completed at depths not exceeding 1200 ft., provided that such installations do not exceed an average of one well to five productive acres.

The new Supplementary Order applies only to oil wells and the existing restrictions on the use of material for drilling and completing gas wells remain unchanged. If, in the course of drilling operations under the new Supplementary Order, a gas well is obtained, application for an exception must be filed with the PAW District Office before completion as a gas well.

The following areas in the three states are affected:

EASTERN KANSAS—That portion of the State of Kansas which lies east of the Sixth Principal Meridian and south of the Northern boundary of Township 15 South, plus the Counties of Jefferson, Leavenworth, Wyandotte, Douglas and Johnson.

EASTERN AND SOUTHERN OKLAHOMA—That portion of the State of Oklahoma which lies east of the West boundary of Range 4 West, and also that portion which lies south of the North boundary of Township 11 North and west of the West Boundary of Range 4 West.

NORTH AND WEST CENTRAL TEXAS—The counties of Archer, Baylor, Brown, Callahan, Clay, Coleman, Comanche, Cooke, Eastland, Fisher, Foard, Haskell, Jack Jones, Montague, Palo Pinto, Shackelford, Stephens, Taylor, Throckmorton, Wichita, Wilbarger, and Young.

PAW officials state that the new order is issued to stimulate the development of new reserves by the many small operators in this area. A large number of these operators own their own shallow drilling rigs and, as second-hand material can be used advantageously, it is hoped that search will be intensified for previously overlooked shallow oil fields on small structures, and in non-structural sand lenses.

Although it is realized that this area has been combed thoroughly, the development of any new fields, or extensions of existing fields would produce oil advantageously located with respect to existing transportation facilities. The oil found is usually of very desirable quality and would be a welcome addition to the supply for refineries making war products in PAW District 2, which are experiencing difficulty in obtaining an adequate supply of crude.

Southwestern Michigan Spacing

A comprehensive plan affecting spacing requirements for the drilling of shallow oil wells in 12 counties in Southwestern Michigan was announced recently by the Petroleum Administration for War in Supplementary Order No. 7 to Petroleum Administrative Order No. 11.

In the counties of Allegan, Barry, Berrien, Branch, Calhoun, Cass, Kalamazoo, Kent, Muskegon, Ottawa, St. Joseph, and Van Buren, oil wells may be drilled or deepened to depths not greater than 2000 ft. on a basis of 20 acres per well, instead of the 40 acres per well required by the general terms of PAO No. 11.

Wells complying with the 20-acre spacing requirements of Supplementary Order No. 7 are eligible for priorities assistance in securing necessary materials without any application for an exception to PAO No. 11.

Arkansas Development

Specific provisions for the development of the Dorcheat-Macedonia oil and gas field in Columbia County, Arkansas, has been announced by the Petroleum Administration for War in Supplementary Order No. 9 to Petroleum Administrative Order No. 11.

In this field, gas and condensate are produced from the Smackover Lime, and both gas and oil are found at shallower depths in several irregular lenticular sands in the Cotton Valley formation. The productive area of the Smackover Lime is not as extensive as that of the Cotton Valley formation.

Prior to the Supplementary Order recently issued, each proposed well had to be handled as an exception and permission to use material granted on an individual basis. The Oil and Gas Commission of the State of Arkansas has carried on hearings and studies relating to the further development of this field and the new order represents the views of the Arkansas authorities, the operators in the field, and the Petroleum Administration for War.

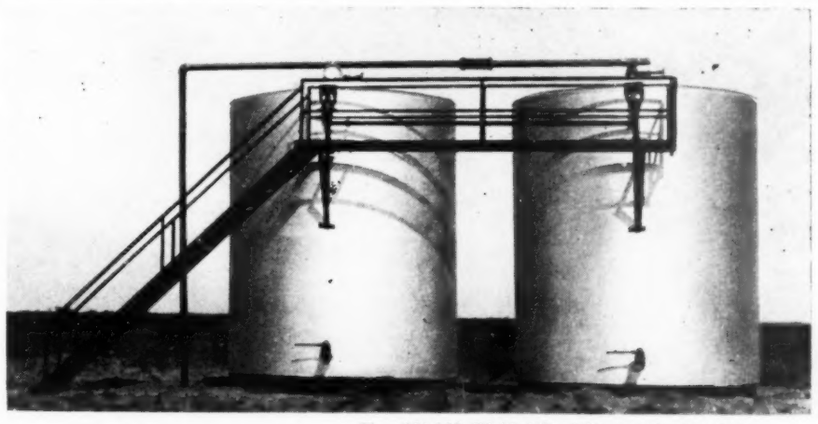
Under the new order, materials may be used and wells drilled without application for exception, provided they conform to the following conditions:

1. All wells must be drilled on at least an 80-acre drilling unit located entirely in either the north or south half of a regular quarter section. The well location must be within 150 ft. of the center of the drilling unit.
2. Where the Smackover Lime is productive, wells must be drilled to and produced from the Smackover. If the operator desires, however, he may dual complete so as to produce also from the Cotton Valley formation. In lieu of the foregoing, the operator is given the option of consolidating a quarter section of 160 acres upon which may be drilled or recompleted two wells provided that such wells are located in the approximate centers of the north or south 80-acre halves and one of the wells is drilled to and completed or recompleted in the Smackover Lime.
3. Where the Smackover Lime is not productive, wells must be drilled to and produced from an oil sand in the Cotton Valley formation, but may be dual completed, if the operator desires, in two pays within the Cotton Valley formation to produce both oil and gas.
4. Dual recompletions are provided for under the following conditions:

a. Wells now producing only from the Smackover Lime may be dual-recompleted to produce either oil or gas from the Cotton Valley formation in addition to the production from the Smackover Lime.

b. Wells drilled to the Cotton Valley formation, where the Smackover Lime is not productive, may be dual-recompleted to produce both oil and gas from separate sands within the Cotton Valley formation.

5. All dual completions and dual recompletions must be so made that the production from the separate formation or sands is not commingled in the well.



Two 150-bbl. Welded Steel Storage Tanks, Steel Foundation Rings, Steel Stair and Walkway.

HANLON-WATERS INC. H-W

STANDARD FOR PERFORMANCE

Bolted Steel Tanks

A.P.I. Bolted Steel Tanks of all standard sizes and gauges, walkway, stairway and accessory equipment carried in stock. Vapor Control Valves for maintenance of gravity and volume.

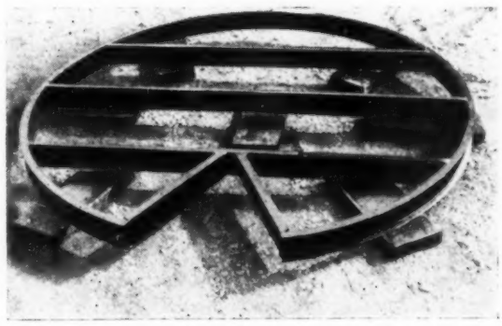
Welded Steel Tanks

Welded Steel Tanks for Oil Country use are stocked for immediate delivery in 100, 150, 210 and 250 bbl. sizes. New steel only, used in welded tanks, expert fabrication. Combination Pressure-Vacuum Thief Hatches, Foundation Rings, Stairs and Walkways. Welded Steel Tanks stocked only at Wichita Falls, Texas, for delivery to any point.

Consult the nearest H-W Office on all your tank requirements; TULSA; HOUSTON, WICHITA FALLS, BRECKENRIDGE, ODESSA, CORPUS CHRISTI, Texas; SHREVEPORT, Louisiana

HANLON-WATERS, INC.

TULSA, OKLAHOMA



H-W AUTOMATIC CONTROL EQUIPMENT; New York, Chicago, Pittsburgh, Philadelphia, St. Louis, Denver, Los Angeles, Shreveport, La., Fort Worth, Houston, Corpus Christi and Odessa, Texas.

Steel Foundation Ring with Footing Boards used under Welded Steel Storage Tanks

Mexico Featured at Nomads Meeting

Mexico, by picture and speech, was the feature of the regular monthly dinner meeting of the Los Angeles Chapter of Nomads held recently. This meeting was preceded by a short business meeting at which four new members were elected. Owing to the press of war work, the sergeant-at-arms, J. V. Robinson, has had to resign his office and Fred Tyler was elected to that post.

After dinner, President Pullman turned the meeting over to the master of ceremonies for the evening, M. E. Montrose. On behalf of the Chapter and as a token of esteem by its members, a gavel was presented to Past President W. F. Bettis.

Three new members were inducted by Induction Master C. J. McLaren and Master of Ritual M. E. Montrose. These were John F. Dodge and Dan Duncan as regular members and Ralph K. Beall as associate member. Howard H. Harmon could not be present for induction as a regular member because of absence in Canada at the time of the meeting.

After a short intermission for the arrangement of seats, motion pictures (in color) were presented by Walter Wells. These were remarkably fine pictures and gave excellent shots of many places of interest throughout Mexico.

The speaker of the evening was Hon. Carlos Grimm, vice-consul of Mexico, who spoke on the attitude of Mexico during the war. Unlike during the previous world war, the Mexican people as well as the government, are 100 percent pro-United States, he said.

Among the guests were the following from other countries: C. A. Lilly of California Arabian Standard Oil Company from Saudi Arabia; J. C. Russell of Y.P.F. of Bolivia from Bolivia; Harry M. Heath of The Texas Company from Caracas, Venezuela; Dave Dimitt of the International Petroleum Company from Ecuador; J. A. Pryde of Shell of Colombia from Colombia; E. A. Brown and B. Beck of Caribbean Petroleum from Venezuela.

AMERICAN FULL ROLLER BEARINGS are *engineered* to give super bearing performance in the most ponderous, powerful equipment, required for extra heavy-duty service. Specifically built to withstand terrific strains and stresses, AMERICAN FULL ROLLER BEARINGS, function smoothly, flawlessly under the most gruelling service conditions. Rugged durability and long life—often outlasting the equipment itself—plus continuous, trouble-free performance, have established their leadership under all conditions requiring bearings capable of withstanding brutal punishment and abuse. Once adopted, no equipment manufacturer has ever had to switch from AMERICANS.

Specify AMERICANS in your next full-roller application. AMERICAN specialized engineering experience is at your service.

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AMERICAN ROLLER BEARINGS HEAVY DUTY

AMERICAN
Heavy-Duty ROLLER BEARINGS

Littell Heads P.I.E.A.

F. W. Littell, Shell Pipe Line Corporation, Houston, Texas, was chosen president of the Petroleum Industry Electrical Association for the coming year. Other officers are: R. C. Appling, Shreveport, Louisiana, United Gas Pipe Line Company, vice-president, and J. F. Collerain, Houston Pipe Line Company, secretary-treasurer.

New officers of the Cathodic Section include R. A. Brannon, Houston, Humble Pipe Line Company, chairman; William E. Huddleston, Bartlesville, Cities Service Gas Company, vice-chairman, and R. H. Crowe, Tulsa, Stanolind Pipe Line Company, secretary-treasurer.

Wrather Heads Survey

William Embry Wrather, one of the nation's outstanding consulting petroleum geologists, was sworn in recently as Director of the Geological Survey of the Department of the Interior at a ceremony in the office of Secretary of the Interior Harold L. Ickes. He succeeds Dr. Walter C. Mendenhall, who retired last February after 48 years' service in the Survey.

R. R. Zisette Sales Manager SKF

The appointment of Robert R. Zisette, as general sales manager of SKF Industries, Inc., Philadelphia, Pennsylvania, manufacturers of ball and roller bearings, has been announced by Richard H. DeMott, vice-president in charge of sales.

National Supply Again Honored

The National Supply Company was the recipient of its fourth War Production Award on May 19 with the presentation of the Army-Navy "E" to the employees of its Torrance, California, plant. The three previous awards consisted of the Army-Navy "E" at the Ambridge, Pennsylvania, and Toledo, Ohio, plants, and the U. S. Maritime Commission Victory Fleet Flag and Maritime M Pennant to the Superior Engine Division at Springfield, Ohio.

The principals who participated in Army-Navy "E" ceremonies of National Supply Company

Presentation of the Award was made to President A. E. Walker by Lt. Col. Lawrence C. Ames, A.A.F. Col. Ames paid tribute to The National Supply Company on its excellent record of achievements in the production of War Materials.

Army-Navy "E" Pins were presented to Reese James of 43 years' service, and to Miss Calista Washburn of one year service, representing plant employees; and to Miss Georgia Farley of 28 years' service, representing office employees. Pins were accepted in behalf of all employees by A. J. Hetzel, chairman, The National Supply Company Unit O. W. I. U., Local No. 128.

Rear Admiral Jos. R. Defrees, U.S.N. retired, Inspector of Naval Material, Los Angeles District, gave the principal address and paid tribute to the workers and management for their achievements.

Mann Promoted by G. E.

W. A. Mann has been appointed assistant manager, Industrial Division of General Electric Company's Central District, Chicago, it has been announced by W. O. Batchelder, commercial vice-president.

Mann was born in Kansas City, Missouri. After graduating from the University of Illinois in 1923 with a B.A. degree in electrical engineering, he became associated with General Electric's turbine department at the Schenectady Works. Later the same year he entered the test course there.

In 1925 Mann was transferred to the Industrial Engineering Department at Schenectady, and early in 1926 he was transferred to the Industrial Department there. Soon after, he was transferred to the Chicago office.

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COULD PUT ON A
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Hill-Hubbell Steel Pipe Protection is applied at these leading mills:
JONES & LAUGHLIN STEEL CORPORATION
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If you could tear down Hill-Hubbell Steel Pipe Protection, you would see why OUR construction is superior, why FACTORY applied protection is more thorough. Since the cost is no more, why be satisfied with anything less?
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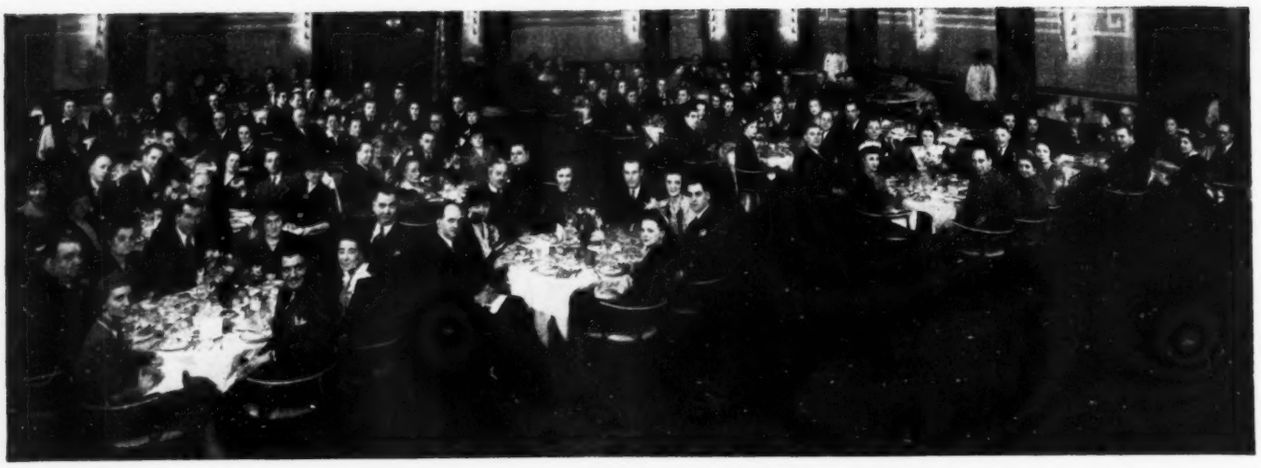
HILL, HUBBELL & CO. • Division • Cleveland, Ohio
• EXPORT OFFICE: SAN FRANCISCO, CALIFORNIA, U. S. A. •



Pemco Foremen Meet

A dinner at Hotel Webster Hall in Pittsburgh was recently sponsored by the Foreman's Association of the Pittsburgh Equitable Meter Company. Officers of the company, department heads, and invited guests were welcomed by Carl Dixon, plant superintendent, who served as master of ceremonies. Short talks were given by Colonel Rockwell, president, and other members of the supervisory force. Entertainment and dancing followed the dinner.

Appoints Canadian Agent

Appointment of Gunite and Waterproofing, Ltd., 1538 Sherbrooke Street, West Montreal, Canada, as Canadian distributors for Amercoat has been announced by American Pipe and Construction Company, Los Angeles, California, manufacturers of corrosion-resistant thermoplastic coatings for steel, concrete, and wood.

Gunite and Waterproofing, Ltd., will handle distribution of Amercoat Products in Canada, serving war industries, food and chemical industries, general industry, and the marine field.

PROTECT YOUR LINES

WIRE LINE GUIDE

PATTERSON BALLAGH

CORPORATION

Los Angeles Houston New York City

TRADE LITERATURE

What to Write For

DATA ON MIDWEST ELBOWS and other welding fittings have been collected in a new booklet, Bulletin WF-41, by the Midwest Piping and Supply Company, 1450 South Second Street, St. Louis, Missouri, that will be sent upon request. Factual reports are given on the exceptional dimensional accuracy and uniformity of the Midwest welding fittings that improve piping design.

LUFKIN RULE COMPANY, Saginaw, Michigan, will send Catalog 12-c to those interested in pictures and descriptions of modern precision tools. Tapes, rules, and other tools are listed in the publication.

COMPLETE ILLUSTRATIONS and descriptions of Armstrong pipe dies and chasers have been published in Catalog C-39a, which may be obtained upon request. These dies, that fit all standard makes of stocks and threaders, are made by Armstrong Brothers Tool Company, 331 North Francisco Avenue, Chicago, Illinois.

A 20-PAGE BOOKLET on vertical axial and mixed-flow pumps has been released by Ingersoll-Rand Company and copies—Form 7073—may be obtained at any branch office or from the home office, 11 Broadway, New York City. Design and construction are amply illustrated. The units described are designed for pumping large volumes of liquid at comparatively low heads.

COPIES OF A NEW ELECTRODE COMPARISON CHART are available through G. Van Alstyne, Air Reduction Company, 60 East 42nd Street, New York City. The chart details the principal AWS and ASTM electrode classifications and indicates which electrodes produced by 20 leading manufacturers meet the different requirements.

MATERIALS AND METHODS for cleaning and germicidal treatment of respirators, goggles, helmets, etc., are found in a special service report on servicing of this equipment. Oakite Products, Inc., 48 Thames Street, New York City, assembled the report in a five-page bulletin available upon request.

FOR DESCRIPTION of power distribution air-cooled Noflamel (non-inflammable liquid filled) transformers and their advantages in engineering and manufacturing Bulletins No. TU-33, TU-181, and TU-180 will be sent by Wagner Electric Corporation, 6400 Plymouth Avenue, St. Louis, Missouri.

A. E. Higgins in Active Service

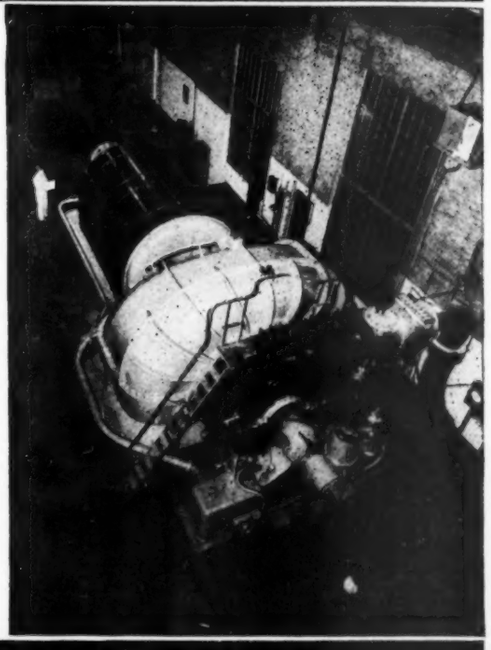
A. E. HIGGINS

A. E. Higgins, vice-president and sales manager for the Pittsburgh Equitable Meter Company—Merco Nordstrom Valve Company, Pittsburgh, Pennsylvania, was commissioned as major in the U. S. Air Corps on May 8, 1943. He was called immediately for active duty. A veteran of World War I, Major Higgins has held a reserve officer's commission.

Prior to associating with the Pittsburgh firm he served as secretary for the Natural Gas Department of the American Gas Association.

Electric Power Is Essential to Victory

TODAY you and every other American have one thought uppermost in mind—Winning of the War! War today is a war of machines, a war requiring mass production. Vital to high speed industrial production is ELECTRIC POWER and it must be available wherever it is needed. The interconnected Texas power grid, of which this Company's transmission system is an important part, has made this possible.



TEXAS ELECTRIC SERVICE COMPANY

E. O. Bennett Enters Consulting Work

Resignation of Dr. E. O. Bennett as chief petroleum engineer for Continental Oil Company, effective June 15, has been announced at the company's offices in Ponca City, Oklahoma.

Bennett, who two weeks ago was awarded an honorary doctor of engineering degree in recognition of his outstanding contribution to engineering science, will immediately establish an office as a petroleum consultant in Houston, Texas, at 342 Mellie Esperson Building, he announces.

An authority on oil production methods, particularly in pressure-maintenance operations in deep, high-pressure oil fields, Bennett was the recipient of the Hanlon Award in 1942 for "distinguished service to the natural gasoline industry," the highest award given in this branch of the petroleum industry.

Dr. Bennett has been with Continental Oil Company since 1926, having served as chief engineer, assistant manager of drilling and production, and chief petroleum engineer, devoting a major portion of his time to development of oil-field operations along the Gulf Coast. During his 26 years of service in the oil industry, Bennett has been granted many patents for pipeline, drilling, and production equipment.

PUMP TUBES and WORKING BARRELS

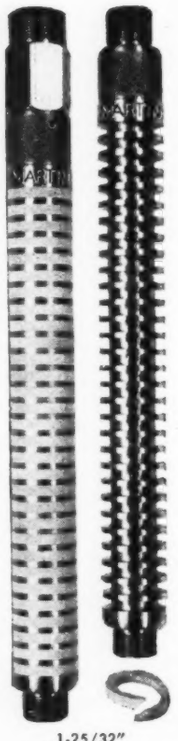
Last Longer . . . . . .

with MARTIN PLUNGERS

By using Martin Plungers, pump tube life is generally increased from two to five times. Only the Martin Resilient Rubber and Fabric Rings come in contact with the tube. These resilient rings cause far less wear than other plunger material.

Further important saving is effected by the Martin patented construction, which gives greater wearing life to the rings and bodies.

Write for Illustrated Catalog or See Composite Catalog



1-25/32" 30 Groove Size

SOLD ONLY THROUGH SUPPLY STORES

Only Martin Plungers have the one-piece "fluid-proof" bodies and "compensated" precision packing rings.

JOHN N. MARTIN
Manufacturer
11 W. Brady St. Tulsa, Okla.

Field Representatives

Tom Hulett, El Dorado, Ark.
Hugh Robinson, Blackwell, Okla.
C. J. Baeten, Wichita, Kansas
F. M. Wilson, Wichita Falls, Texas
Lynn C. Holloway, Houston, Texas
J. Walter Wade, Olney, Illinois
E. C. Dilgarde, Casper, Wyoming

N. G. Guiberson Feted

N. G. Guiberson, vice-president of the Guiberson Corporation, was honored recently with a surprise party marking his 25th year of service with the company in Dallas, Texas.

He came to Texas from California in 1915, selling specialty oil tools developed by his brother S. A. Guiberson, Jr., and has since become a familiar figure in Mid-Continent and Pacific coast oil fields. By 1919, another brother, W. R. (Dick) Guiberson, joined him and plans were made for manufacturing their widely used tools in Texas.

Today, the Guiberson Corporation operates two large war plants in Dallas, and its associate enterprise, the Guiberson Diesel Engine Company has developed America's only air-cooled radial Diesel engine for tanks, boats, and planes.

Most of the four-score officials and key workers of the firm who attended the party have been with the company 14 years or longer. Allen Guiberson, nephew of the pioneer and president of the corporation, was toastmaster.

Wilson Promoted

Harry Wilson, until recently Kobe, Incorporated, district manager in charge of West Texas operations, has been promoted to the management of the company's Oklahoma district and now has his headquarters at the division office in Oklahoma City.

HARRY WILSON

Wilson brings to his new position a well-founded production experience, having joined the Pure Oil Company's production department in 1929 after finishing school. In 1937 he became associated with the Kobe organization and contributed to some of the early applications of hydraulic pumping in the Oklahoma City field. In 1939, Wilson was made district manager for Kobe, Incorporated, in charge of West Texas and New Mexico, which operations he developed until his recent promotion.

Burdette Blue Passes On

BURDETTE BLUE

A leader in the oil industry, Burdette Blue, 57, died suddenly of a heart attack as he was lunching with friends at the Tulsa Club, Tulsa, Oklahoma. Blue was president of the Kansas-Oklahoma division of the Mid-Continent Oil and Gas Association and kept active in the petroleum industry.

He rose rapidly to prominence from 1917 when he gave up general practice to become general counsel for Indian Territory Illuminating Oil Company. After holding the post as vice-president and general manager Blue became president in 1936, resigning in 1941 when the firm was taken over by the Cities Service Company. He continued with the new management in an advisory capacity.

Egloff Receives Medal

Dr. Gustav Egloff, director of research of Universal Oil Products Company, Chicago, Illinois, is the 1943 recipient of the Columbia University Medal of Merit, which is awarded annually to an outstanding scientific or technological leader in industry.

The medal was presented at the convocation of the university on June 1.

Dr. Egloff has been prominent for more than 25 years in research and invention and in the development of processes for the refining of petroleum, gasoline, natural gas, and oil shale. At present, in addition to his duties with Universal, he is active as an adviser to various government agencies having to do with petroleum, and spends much of his time in Washington.

Ladd Heads A.P.I. District

Herbert W. Ladd, superintendent of materials, Stanolind Oil and Gas Company, Tulsa, was elected chairman of the Mid-Continent District, Division of Production of the American Petroleum Institute at the spring meeting in Tulsa. Other officers are: H. F. Beardmore, Amerada Petroleum Corporation, vice-chairman for Oklahoma; S. K. McLanhan, Mid-Continent Petroleum Corporation, vice-chairman for Kansas; R. T. McNally, Shell Oil Company, vice-chairman for the Panhandle, and J. S. Montgomery, Phillips Petroleum Company, secretary-treasurer.

Bergeron California Sales Manager for Baash-Ross

Announcement has been made of the appointment of Frank E. Bergeron as California sales manager for the Baash-Ross Tool Company, succeeding B. Bronzan who is now devoting his full time to general managership of the organization.

Bergeron, by reason of his widespread knowledge of the industry, is well qualified for his new post. After graduating from UCLA he gained three years' mining experience before going with the Baash-Ross organization in 1935. After several years in the shop, gaining experience in the design and operation of the Baash-Ross products, he went into sales office work, followed by a four-year period as field sales representative. In his new capacity he has charge of oil tool sales for the California division of Baash-Ross.

Open Kansas Store

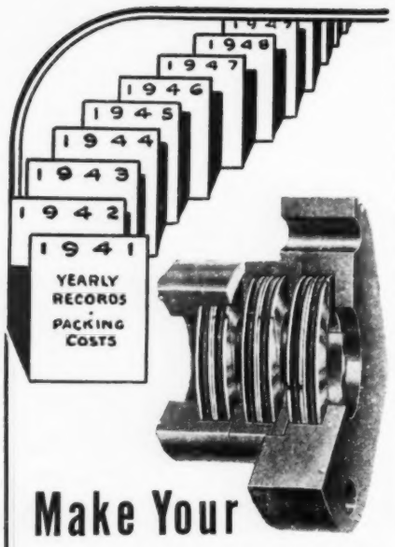
Bethlehem Supply Company, Tulsa, Oklahoma, on June 15 opened a new store at 414 South Main Street, Pratt, Kansas, to provide better service in that area.

Speaking of STAMINA—
"CLEVELANDS"
REALLY HAVE IT

That's Why They're Delivering Maximum Ditch Day In and Day Out On So Many War Emergency Pipe Line Projects

"CLEVELANDS" modern engineering, correct design coupled with super-quality materials and the best in construction, delivers you hundreds of hours of operation without major repairs—and at rock bottom cost for operation and maintenance. • Amply powered and with a speed for practically every ditching need "CLEVELANDS" cut through the toughest going in all types of soil and terrain.

THE CLEVELAND TRENCHER COMPANY
20100 ST. CLAIR AVE. "Pioneer of the Small Trencher" CLEVELAND, OHIO
"CLEVELANDS" Save More . . . Because they Do More



Make Your Next Packing Job *L-A-S-T!*

During these days of increased production, it is especially annoying and costly to experience shutdowns due to packing trouble.

There is a solution. Install France "Full-floating" Metal Packing in your engines, pumps and compressors. The result is increased efficiency. And each job lasts for years without maintenance expense. Saves money, too, in the long run.

Installation is a simple procedure. See that the rings are installed as lettered to correspond with similar letters on the case. As simple as A-B-C. Write for details and Catalog M-3. Make your next packing job L-A-S-T!

ORIGINAL FRANCE METAL PACKING
Sold on approval
Satisfaction Guaranteed

THE FRANCE PACKING COMPANY
Tacony Philadelphia Penna.
Mid-Continent Representative:
Mr. J. M. FULLER, 3725 West 7th Street
FORT WORTH, TEXAS

Original FRANCE METAL PACKING

Harrington Officer of Hunt

George G. Harrington has become a member of the firm of Hunt Tool Company, Inc., Houston, Texas, effective May 15, and was elected vice-president in charge of engineering and research. He also was elected a member of the board of directors of the company.

G. G. HARRINGTON

After 19 years' service in the engineering department of Reed Roller Bit Company, the last 11 years of which he was chief engineer, Harrington recently opened a consulting engineering office in Houston. He is a graduate in engineering from the University of Texas with the degree of bachelor of science in mechanical engineering, is a member of Tau Beta Pi, engineering fraternity, and an honorary member of the mechanical engineering fraternity, Pi Tau Sigma. He is chairman of the Texas Chapter of the American Society for Metals.

Bedell Joins Graver Tank

Announcement has been made of the appointment of A. E. Bedell as chief engineer of Graver Tank and Manufacturing Company, Inc., in charge of engineering and development covering all divisions of the company.

A. E. BEDELL

Formerly associated with Max B. Miller and Company, Inc., and for 14 years in charge of engineering for that company, Bedell has had vast experience in the construction of refinery equipment, supplemented by previous experience in the chemical, power, sugar, and general industrial fields.

Bedell's headquarters will be in the general offices of the company at East Chicago, Indiana.

Complete Fuel Utilization

is greatly advanced by corrosion free boilers and tubes—that's the function of Sand-Banum.

BTU's consumed do not determine delivered power, steam or heat. As an instance, 1/32 of an inch of scale requires a surplus fuel consumption of 10%; 1/8 of an inch 25%.

SAND-BANUM Automatically Frees Boilers and

tubes of scale and corrosion, and keeps them free, in absolute safety to personnel and equipment.

"The Entirely Different Boiler and Engine Treatment"

To lengthen equipment life, to promote maintained operating efficiency, and to advance economy, write today for Sand-Banum data and details of test on satisfaction guaranteed or no money basis.

AMERICAN SAND-BANUM COMPANY, Inc.
9 Rockefeller Plaza New York City

Look for the Arm-and-Hammer
ARMSTRONG BROS.

Long Lasting DIES and CHASERS

ARMSTRONG BROS. Pipe Dies and Chasers make pipe threading easier, cut smoother, closer fitting threads and hold their keen edge longer because of important design improvements, superior material and modern controlled manufacturing methods. All have the correct Cutting Angle, the correct Throat Angle and provide Ample Chip Clearance. All are machined from Special Vanadium Tool Steel, carefully hardened, drawn, tempered and tested.

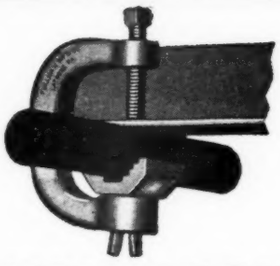
Armstrong Bros. Dies fit all standard makes of stocks and threaders.

Write for catalog C-39a for complete showing and description of Armstrong Pipe Dies and Chasers.

ARMSTRONG BROS. TOOL CO.
"The Tool Holder People"
331 N. FRANCISCO AVE. CHICAGO, U.S.A.
Eastern Warehouse & Sales: 199 Lafayette St., New York

Latrobe PRODUCTS

★FLOOR BOXES ★ WIRING SPECIALTIES★



"BULL DOG"
PIPE or CONDUIT HANGER

This handy hanger is adaptable for such wide range of use, is so easy to install and gives such trouble-free service that it has come to be considered a necessity around refineries, mills and factories. Made of high-quality malleable iron — saddle turns for pipe to run parallel or at angle to beam. And best of all it holds.

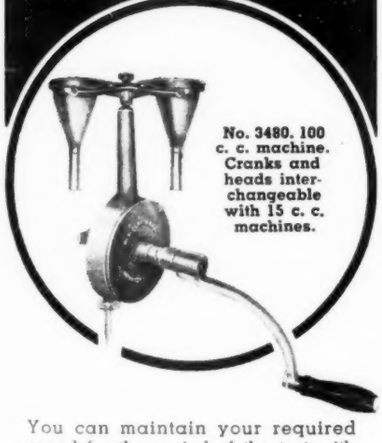
"BULL DOG" Insulator Supports

Ideal for fastening porcelain and glass insulators to exposed steel framework—made of malleable iron.

Jobbers' inquiries invited. . . . Price list and complete information upon request.

FULLMAN MANUFACTURING CO.
LATROBE . . . PENNSYLVANIA

GET ACCURATE RESULTS
Quickly . . Easily . . with
CURTIN CENTRIFUGES



No. 3480. 100 c. c. machine. Cranks and heads interchangeable with 15 c. c. machines.

You can maintain your required speed for the period of the test with much less effort. Curtin centrifuges, proven world-wide, are heavy duty, rigidly constructed, and extremely simple in design. Illustrated bulletin, giving full details, available upon request.

W·H·CURTIN & CO. Inc.
HOUSTON U·S·A TEXAS

Shimer to Cooper-Bessemer

J. M. SHIMER

Officials of The Cooper-Bessemer Corporation, Mount Vernon, Ohio, have announced the appointment of John M. Shimer to the post of research engineer. He will play an essential part in Cooper-Bessemer plans aimed at furthering the war effort, particularly as these plans relate to the oil and gas and associated industries.

In his work for Cooper-Bessemer, long a major supplier of engines and compressors, Shimer will investigate, for example, the adaptation of new materials, conservation of critical materials and the refinement of design where, in view of changing requirements, greater effectiveness will result.

Shimer's wealth of experience makes him well suited for this specialized engineering position with Cooper-Bessemer. A graduate engineer of Lafayette College, he was in charge of the Willson-Snyder Manufacturing Corporation's engineering and manufacturing for nine years, and for 12 years was vice-president in charge of engineering with the Oil Well Supply Company.

Shimer will have his headquarters at Cooper-Bessemer's Dallas, Texas, office where he will be in effective contact with the critical oil and gas industry and other vital industries.

Occupies New Plant

The Ridge Tool Company, Elyria, Ohio, has recently moved from its original factory site at North Ridgeville into completely remodeled and modernized plant and offices in the city of Elyria. Increased business of the makers of Ridgid pipe tools has for some time made expansion of manufacturing facilities necessary; plans have been speeded up in the last few months because of increased jobber and war orders. The new factory provides five times the working space of the old and permits greater manufacturing efficiency. A feature of the new offices is an attractive mural 22 ft. long by 3 ft. deep in the reception room, painted by Glenn Shaw of the Cleveland School of Art; it depicts the uses of Ridgid pipe wrenches, threaders, cutters, and vises in many industries. The Ridge Tool Company is 20 years old.

EVER since the discovery of oil, The Petroleum Industry has constantly developed new weapons to conquer the inexorable forces of Nature. New materials . . . new equipment . . . new methods . . . already proved and accepted have prepared it for the present emergency. Whereas other industries have had to re-tool to meet the emergency of war, the Petroleum Industry is ready NOW!

A typical example in Petroleum Industry preparedness is the CHIKSAN *All-Steel* Rotary Hose . . . developed and proved long before material shortages were even dreamed of. Curtailment of rubber, therefore, need work no hardship on the driller . . . it need not retard needed drilling of new wells . . . because CHIKSAN Rotary hose has already proved its ability to serve in this field! Hundreds are now in use as standard equipment.

●

4" and 5" Sizes for DRILLING SERVICE
3" for STANDBY and PRESSURE SERVICE
45' - 50' - 55' - 60'
STANDARD LENGTHS
LONGER LENGTHS to ORDER

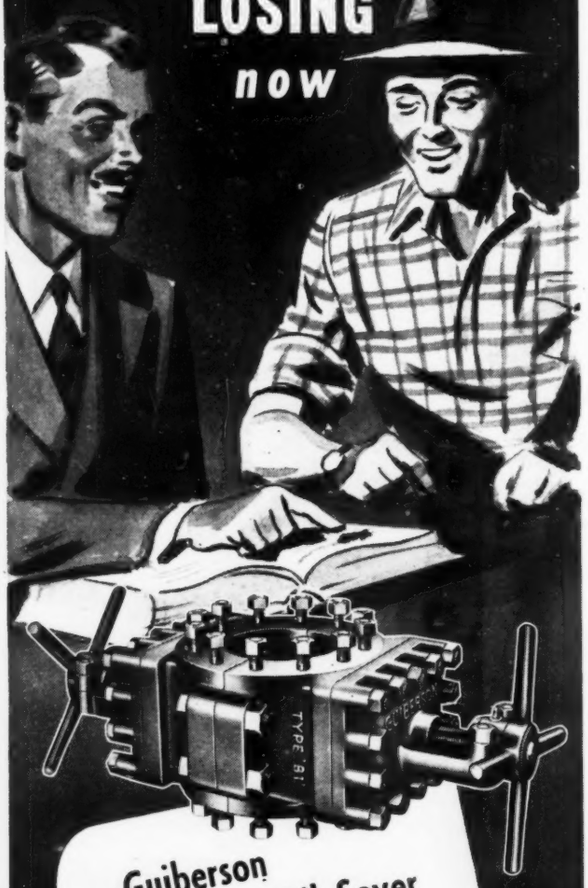
●

GULF ENGINEERS, INC.
Distributors in Texas, Louisiana, Arkansas and New Mexico

WELL EQUIPMENT MFG. CO.
Distributors in Oklahoma and Kansas

CHIKSAN TOOL COMPANY
BALL BEARING SWING JOINTS for ALL PURPOSES
BREA, CALIFORNIA
ALL-STEEL ROTARY HOSE
CIRCULATING HEADS · MUD GUNS

here's how we can save the oil we're LOSING now



Guiberson Type B-1 Oil Saver

Waste, always inefficient, is inexcusable in wartime — and that includes the oil that is usually lost while drilling in, working tubing and running rods. The GUIBERSON OIL SAVER is a **positive** and **performance-proved** means of preventing this waste, and turning the oil now lost into **profit.** See your Composite Catalog — or write for details.

THE GUIBERSON CORPORATION
DALLAS, TEXAS

Export Representative: I. FRANK BROWN
30 Rockefeller, Plaza, New York City
Calif. Distributor: W. R. GUIBERSON CO.
723 East Gage Ave., Los Angeles, Calif.

Now supplying critical materials to the Army, Navy, Marines and Army Air Forces

GUIBERSON
LIFE EXTENSION SERVICE FOR OIL WELLS

Book Reviews

Mathematics Dictionary, edited by Glenn James, assisted by Robert C. James. Published by The Digest Press, Van Nuys, California. Pages, 327. Price, $3.

Covering all the basic words and topic phases used in mathematics, the new "Mathematics Dictionary" is essentially a condensation of the science from arithmetic to integral calculus. Engineers who have seen advance copies believe it will prove a convenient reference book, especially in cases where only a short explanation of a term is needed. Terms are listed alphabetically and include those used in arithmetic, algebra, plane and solid geometry, mathematics of finance, trigonometry, analytic geometry, differential and integral calculus. Formulas and tables are in an appendix. Glenn James is associate professor of mathematics, University of California.

Houston Receives NIAA Charter

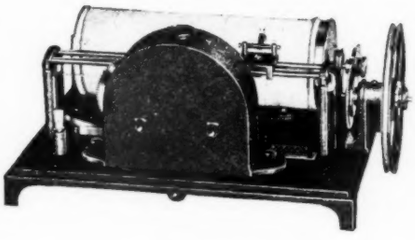
Recently, Allen P. Colby, vice-president of the National Industrial Advertisers' Association and advertising manager of National Supply Company, presented the national charter to the newly organized Industrial Advertisers' Association of Houston, Texas. This is the 27th chapter of the NIAA and the first to be organized in the Southwest. Organized with 27 members, the Industrial Advertisers' Association of Houston

Left to right: A. S. Volpin, A. B. Penny, Lewis A. Thompson, Allen P. Colby, and Harry Heller

has the second largest charter member roll of any of the 27 chapters in the nationwide organization. It is headed by the following officers: A. B. Penny, advertising manager Humble Oil and Refining Company, president; Harry Heller, advertising manager Reed Roller Bit Company, vice-president; Lewis A. Thompson, assistant advertising manager Hughes Tool Company, secretary, and A. S. Volpin of the McEvoy Company, treasurer. At the same meeting, which was the first official one of the new organization, the following were elected to serve with the four officers on the board of directors: Earl Brennan, Brennan-Brown Advertising Agency; Kenneth Fellows, Houston Natural Gas Company; Dick Yancy, Gray Tool Company; George Forristall, Brochstein's, Inc., and Robert J. Koch, Morse Chain Company.

Stevens

LIQUID LEVEL RECORDERS



Type F Recorder

Automatic, graphic records of tank levels from which volume of flow per unit of time may be determined.

•

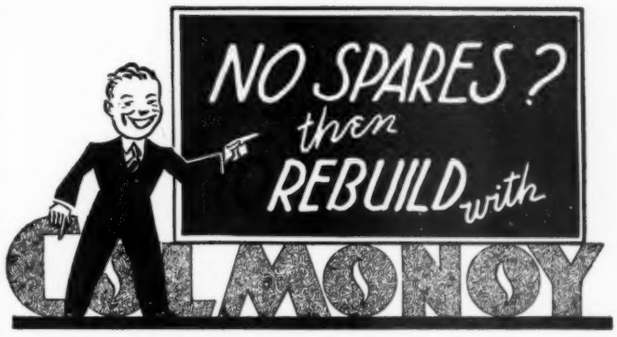
Automatic records reduce operating costs and conserve manpower!

•

LEUPOLD & STEVENS INSTRUMENTS

Hydrographic L&S Surveying

4443 NE Glisan Street Portland, Oregon



Remember when you could call up in the morning and have a new replacement part delivered in the afternoon?

Now it's quicker—cheaper—to hard-surface all wearing parts with COLMONOY. Equipment that must take a lot of punishment—perhaps for 24 hours a day—will operate efficiently, with less wear, when the proper grade of COLMONOY is used as a hard-facing for all parts subject to excessive abrasion and corrosion. It will pay *you* to investigate!

WRITE TODAY FOR CATALOG

WALL-COLMONOY CORP.

720 Fisher Bldg., Detroit, Mich.

Branches in New York City, Blasdell, N. Y., Chicago, Tulsa, Los Angeles, and in Canada

COLMONOY

Hard Surfacing Alloys and Overlay Metals

...QUARTER-CENTURY Prefabricating experience

Working NOW FOR U.S. BUT LATER FOR You!

For more than a quarter-century we have specialized in the industrial-housing field; we were in the vanguard, too, in establishing the validity of the prefabrication principle.

Now—we are in full production, serving industry in its war requirements . . . After VICTORY, we'll be on the alert to serve again civilian needs.

BUY A HOME IN THE PEACE TO FOLLOW—WITH THE BONDS YOU BUY TODAY

HOUSTON Ready-Cut HOUSE CO.

25 years Prefabricating Houses

POLK AVENUE HOUSTON, TEXAS

ENSIGN CARBURETORS

Working for Victory

ENSIGN Carburetors for Natural Gas, Butane-Propane and Gasoline are playing an important part in the Victory effort. We are proud of this fact and are devoting our modern facilities and long experience to the successful completion of this assignment. Helping to win the war is our chief duty at this time.

But still available ON THE HOME FRONT

However, ENSIGN Carburetors for Natural Gas, Butane-Propane and Gasoline are still available for uses not directly connected with the war effort. It may take us a little longer than usual to supply the demand for carburetors, but quick delivery of emergency parts is assured.

Now, as always, ENSIGN is unequaled for efficient and economical carburetion.

ENSIGN CARBURETOR CO., LTD.

HUNTINGTON PARK • CALIFORNIA

Prepare, NOW, for post-war demands. Our competent engineering staff is at your service.

Real Production Economy

How to pump a well with more satisfaction and less money has been our sole business for 25 years. What we have learned we build into JENSEN Units. A lot of oil men in a lot of fields think we do a grand job. If you don't know about it, ask for Bulletin No. 27.

JENSEN
BROTHERS MFG. CO.
Coffeyville, Kansas, U. S. A.
Export Office: 50 CHURCH STREET, NEW YORK CITY

SPERRY-SUN

Greater Speed and Accuracy with Sperry-Sun

Quick, sure methods of determining the straightness or direction of drill holes are playing an increasingly important part in the profit picture. Sperry-Sun offers a complete—and completely satisfying—line of well surveying instruments and technical services.

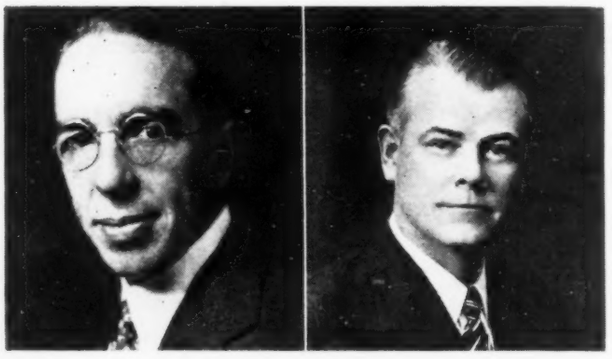
SURWEL Clinograph
SYFO Clinograph
E-C Inclinometer
H-K Inclinometer
H-K Single Shot
M-M-O Bottom Hole Orientation
K-K Whipstock
Polar Core Orientation

SPERRY-SUN WELL SURVEYING CO.
PHILADELPHIA, PA.
HOUSTON, TEXAS LONG BEACH, CALIF.

Lefebvre Named President of Cooper-Bessemer

Announcement of the election of Gordon Lefebvre to the office of president and general manager of The Cooper-Bessemer Corporation, Mount Vernon, Ohio, was released following the annual meeting of the board of directors of that company.

Lefebvre, who has been vice-president and general manager, succeeds B. B. Williams, former president of Cooper-Bessemer, who will remain active in the corporation, continuing his duties as chairman of the board.



B. B. WILLIAMS GORDON LEFEBVRE

Lefebvre is a graduate of Virginia Polytechnic Institute and attended the United States Military Academy at West Point.

His broad business experience includes apprentice and machine work for the Norfolk & Western Railway, after which he became affiliated with E. I. Dupont de Nemours and Company.

In 1919, Lefebvre joined General Motors Corporation where he was placed in charge of production at the Chevrolet plants under William S. Knudsen. Later he was elevated to the post of vice-president in charge of General Motors activities in Canada. He subsequently returned to the United States to assume charge of the corporation's Pontiac division. He was associated with American Locomotive Company in charge of the Diesel engine division prior to joining The Cooper-Bessemer Corporation 19 months ago.

As a member of the Joint War Production Committee of the Economic Defense Board, Washington, D. C., he contributed considerable time and effort towards coördinating the production of war materials in the United States with that of Canada.

MECHANICAL ENGINEER

Engine Research Laboratory engaged in experimental, testing and research on internal combustion engine lubricating oils and fuels and automotive problems needs graduate engineer with dynamometer and engine test experience. Give all details in reply.

ARMOUR RESEARCH FOUNDATION
35 West 33rd Street, Chicago, Illinois

MEETINGS

Pennsylvania Grade Crude Oil Association—June 25, William Penn Hotel, Pittsburgh, Pennsylvania.

Interstate Oil Compact Commission—June 26, Pittsburgh, Pennsylvania.

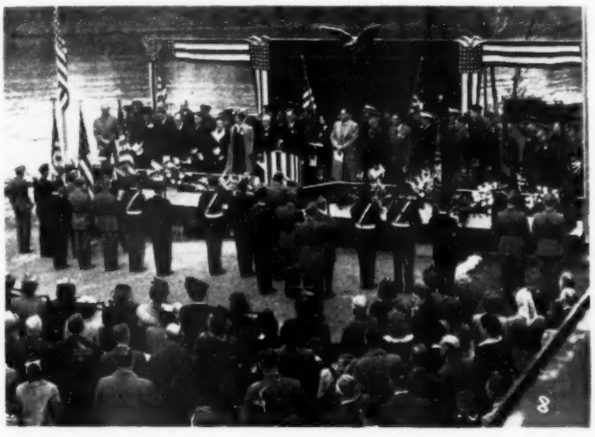
California Natural Gasoline Association, Monthly Meeting—July 1, Barker Bros. Auditorium, 818 West Seventh Street, Los Angeles, California.

American Chemical Society, Petroleum Division, Fall Meeting—September 6, 7, 8, 9, and 10. Place of meeting not determined.

Petroleum Industry Electrical Association and the Petroleum Electric Supply Association—Last week in April, 1944, Dallas, Texas.

Climax Engineering Wins "E" Award

Amid colorful and impressive ceremonies, held recently at the factory site on the Mississippi River, the Army-Navy Production Award was presented to the employees and management of the Climax Engineering Company, Clinton, Iowa.



Raising the National colors at the Army-Navy "E" presentation ceremonies at the factory of the Climax Engineering Company

The coveted "E" banner, in recognition of Climax's high achievement in the production of war equipment, was the first such honor to be awarded in Clinton.

G. W. Dulany, Jr., Climax Board Chairman, gave the introductory address.

Presentation of the award was made by Brigadier General Norman F. Ramsey, Commanding Officer of the Rock Island Arsenal, and accepted on behalf of the company by Edward F. Deacon, president of Climax. Commander A. F. Duernberger, Commanding Officer, Naval Training School, Ames, Iowa, presented the token "E" pins to the employees.

SPANG
CABLE TOOLS
Conserve your equipment to bring Victory closer! And start with the best equipment you can get. For cable-system drilling and fishing, that means SPANG "Higher Standard" CABLE TOOLS. Available at supply stores.
SPANG & COMPANY
BUTLER, PA.

So that there may be no lost time in starting, either with crank or rope; in any weather . . .

To assure positive, trouble-free ignition in operation . . .

To permit quick servicing if and when servicing is needed . . .

WISCONSIN HEAVY-DUTY AIR-COOLED ENGINES are equipped with a weather-sealed, fully accessible, *high-tension impulse-coupling outside Magneto.* A "flywheel magneto" is not good enough even for the smallest Wisconsin Engine.

MOST POWER PER POUND WISCONSIN MOTOR Corporation MILWAUKEE, WISCONSIN, U. S. A.
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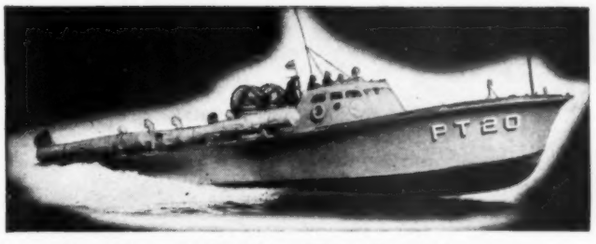

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